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DISCOVERY

THE MAGAZINE OF SCIENTIFIC PROGRESS

Editor WILLIAM E. DICK, B.Sc. F.L.S.

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The Progress of Science

Development of Inventions

BRITONS have long been justified in claiming that in fundamental science we are second to none, and we couple this with an admission that too often we have failed to develop and exploit inventions that arise from fundamental discoveries. A mechanism which may help to avoid such failures in future will be set up when the Development of Inventions Bill, 1938, becomes law. The Bill proposes to create a National Research Development Corporation with two main functions. First, it will secure, "where the public interest so requires", the development or exploitation of inventions resulting from Government research or research financed by public funds, and of any other invention which appears to the corporation not to be receiving sufficient exploitation or development. And second, it will accept, acquire, hold and dispose of rights in such inventions.

Nothing is said directly in the Bill about correcting what is usually reckoned to be this country's greatest weakness in the field of technological development—insufficient use of pilot plant, that is plant constructed in order to carry out a new process on a semi-industrial scale so that all the tricky wrinkles of the new process can be ironed out before proceeding to the building of a full-size industrial plant. But the powers of the Corporation are drawn widely enough to allow of action in this matter.

The scale of activity envisaged appears to be quite large; for the Board of Trade is empowered to advance up to £5 million to the Corporation during its first five years, and in addition it may borrow up to £250,000 from other sources—all this is apart from any finances it may obtain from its own activities. As soon as possible the Corporation is to make its income balance its expenditure. It will be generally responsible to the Board of Trade and through the Board to Parliament, and the Board's specific consent is required for a number of its possible activities.

Like most Acts of Parliament, this leaves one with the impression that very little has been said concretely about how the Corporation will act. But at least a mechanism is established through which one of Britain's major weaknesses could be corrected. When it is established, the usual influences, including informed public opinion, will decide whether the mechanism is only allowed to tick over or is used to maximum effect.

Making Plants Kill their own Pests

INFORMATION has recently been released concerning many new German insecticides. The most remarkable of these are the ones which can be absorbed by a plant to render it toxic to sucking and biting insect pests, a treatment which has been described as 'plant chemotherapy'.

In 1934 Dr. Gerhard Schrader commenced a search for new types of insecticides in the laboratories of the I.G. Factory at Leverkusen. He started his investigation with an examination of organic compounds containing fluorine, as this field was almost unexplored. Encouraging results were obtained, and the range of compounds under review was increased to include organic derivatives of phosphorus, and of these alone over two thousand were made and tested. Materials were found with a very high toxicity towards insect pests which were as good as or better than existing conventional sprays such as nicotine or arsenical solutions, or which could exert their action as a vapour and so be used as fumigation agents. One of these phosphorus compounds, *hexaethyl tetraphosphate*, was manufactured and sold in Germany under the name of 'Bladen', and was claimed to be as efficient as nicotine, then unobtainable. This compound is now available in Britain.

The two new insecticides mentioned recently in DISCOVERY (February, 1948, p. 64), were also discoveries of Schrader, and one of these, *diethyl nitrophenyl thiophosphate*, is being manufactured in this country and should be on sale later this year. The mode of application of these materials is similar to that of the more familiar DDT and Gammexane. During the investigation, the compound called *fluoroethanol* was prepared (it is made by substituting a hydrogen atom in the molecule of ordinary alcohol with a fluorine atom), and certain derivatives called *acetals* were prepared by combination with formaldehyde. These chemicals behaved as typical contact insecticides, giving a 100% kill of aphids, for instance, when sprayed as a

0·05–0·1% solution in water. The very interesting observation was made, however, that these acetals were apparently absorbed from the spray by the living plant, both through the leaves and roots, so that the whole plant became poisonous and was protected for several weeks against sap-sucking and leaf-eating pests. The insecticides are also very toxic to animals. To confirm that this kind of insecticide could be absorbed by the plant from the soil, some young maize plants were carefully watered at the roots three times at intervals of three days with an 0·1% solution of one of the acetals and, eight days after the last watering, the plants were cut down at soil level and fed to rabbits. They were readily eaten, and all the rabbits died within 24 hours. (There has already been some speculation about the feasibility of killing rabbits by poisoning the food plants that grow near their warrens.) Caterpillars and aphids placed on plants similarly treated were also killed.

Considerable care would have to be exercised in the use of these materials as their toxicity towards man and animals is a hazard, and their indiscriminate use might result in crops of fruits and vegetables which were poisonous.

But advantage could be taken of these 'internal' insecticides in connexion with insect pests which attack plants in inaccessible positions, such as root-sucking aphids, the grubs in cotton bolls, leaf- and stem-miners, and so on, which are relatively immune from ordinary sprays and fumigants. The Germans early investigated the possibility of controlling the phylloxera pest of vines in this new manner. This aphid attacks the long roots of vines and cannot readily be dealt with by spraying. Carbon disulphide was the standard insecticide used against phylloxera, but this can do great harm to the vines. A trial was made in the Mainz area in which one of the new insecticides was used to combat an outbreak of phylloxera, holes being made in the ground with an iron bar around the vine roots, a solution of the material added and the holes refilled with earth. The result was encouraging as a 90–95% kill of phylloxera resulted, but shortage of labour during the war prevented further trials. (One season's grapes were lost as they were rendered poisonous and unusable, but this was offset by the great advantage that the vines were saved and serious financial loss was avoided.)

Other compounds, including some organic phosphorus ones such as *bis(dimethylamino) phosphoryl fluoride*, have been discovered which have a similar 'plant chemotherapeutic' action, and are closely related to the fluorophosphonates studied at Cambridge during the war (see DISCOVERY, 1946, p. 198; 1947, p. 313).

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Rain to Order

THE 'bombing' of clouds with dry ice to produce artificial precipitations of snow and rain created tremendous interest last year, though attempts made in Britain to repeat the successes achieved in America and Australia were rather conspicuous flops. We published accounts of the earliest experiments (1947, Vol. 8, pp. 33–4, pp. 165–6), and in our comments on the prospects opened up by these experiments of man being able to modify the weather to his advantage we said that legal difficulties might arise if the method were adopted on any large scale. The fear of legal complications has in fact halted in their tracks the first American research team, that of the General Electric Company, to enter this field. As *Fortune* (February 1948) in its most illuminating survey of the subject of weather control said, "There was enough potential litigation in a few pounds of dry ice to tie up G.E.'s legal staff for generations", so the company has put a ban on further experiments by its rain makers until the legal position is clarified. Their director of research suggested that one way out of the dilemma would be for a central rain-making organisation to be set up, and he pointed out that this might need to be an international organisation.

The American Services took over where General Electric were forced to stop. Ability to control the weather would obviously be of military importance, particularly since clouds are possible vehicles to use for the distribution of radioactive dusts and bacterial poisons.

About a million dollars a year is being spent by the U.S. Services on further experiments which are covered by the name 'Project Cirrus'. Results of one of the most impressive demonstrations of weather changing so far organised are seen in the pictures obtained by Project Cirrus and reproduced on page 167. Project Cirrus has already made attempts to deflect hurricanes from their courses, and the results go some way to support Irving Langmuir in his view that "there is a reasonable probability that in one or two years man will be able to abolish most damage effects from hurricanes".

Taboo on Aluminium

THE field for irrational belief is steadily narrowed by experimental fact. The instinct of men to find and cherish taboos is, however, not to be denied; nowhere are old prejudices more closely guarded, or new ones more easily installed, than in the kitchen. Most of us are free from Mosaic inhibitions and do not care whether our meat has been ritually killed or not, preferring to leave the definition of blemish to the Sanitary Inspector rather than Leviticus. The loss of old and respectable traditions leaves room for the entry of modern fads, of which the prejudice against aluminium in cooking is one example.

If those who foster this prejudice are to be believed, the aluminium picked up from domestic cooking utensils is responsible for the increased incidence of cancer of the stomach and bowel and of duodenal ulcers. No experimental evidence is brought forward in support of this view which runs counter to what facts are available.

The widespread use of aluminium in the handling of food is of comparatively recent growth and post-dates the trends in disease referred to. How widespread is the use can be seen from the information now brought together on the application of aluminium and its alloys in the food industry*. The main reason for the welcome aluminium has found is the lack of contamination or harmful effects on a wide variety of biological systems with which it is used in

* *Aluminium and Aluminium Alloys in the Food Industry*, H.M. Stationery Office, pp. 153, 3*s*.

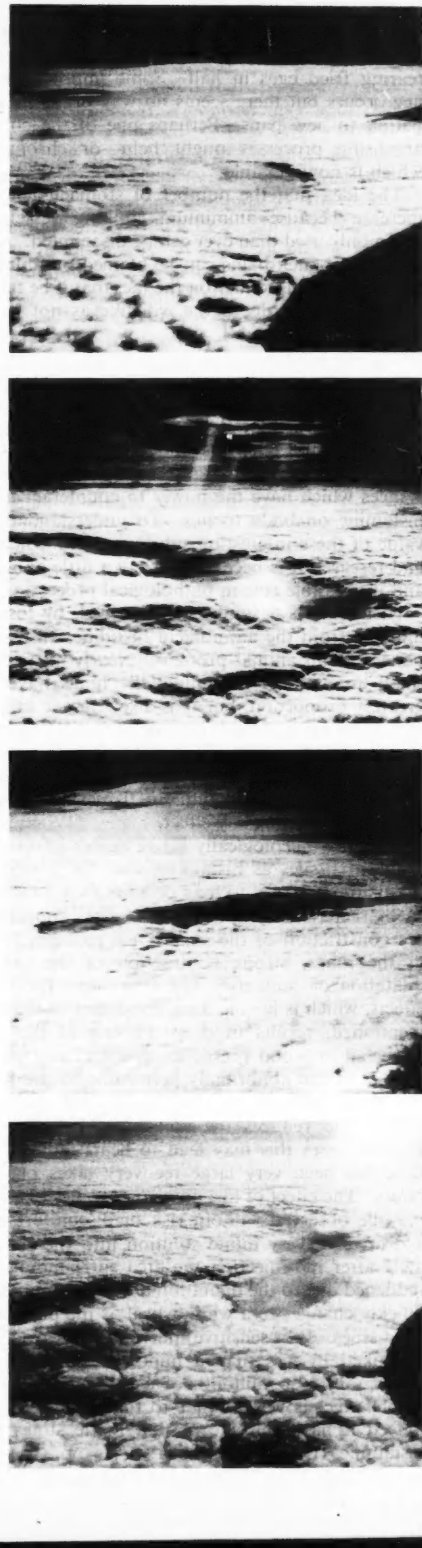

FIG. 1.—At zero hour for this experiment by Project Cirrus a typical stratus cloud was seeded with 25 pounds of dry ice, which was unloaded from a plane flying an L-shaped course. The four photographs were taken after 46, 47, 52 and 61 minutes. The second picture captures the sun's reflection from ice crystals, evidence that water drops had changed to snow. Some of the snow precipitated may have reached the ground, but the purpose of the experiment was to demonstrate that a plane could 'bomb' a hole in a cloud through which it could descend without icing. The L-shaped seeding line eventually developed into a crescent-shaped channel about a mile and a quarter across at its widest region and covering an area of 45 square miles.

contact. The first large-scale use was naturally in one of the largest and most profitable sections of the food industry, the brewing of beer. The ease with which a clean surface could be maintained and brews obtained which were free from contamination with unwanted micro-organisms overcame the general prejudice against any new thing which characterises this industry. It was, therefore, the material to which Chaim Weizmann logically turned for the vessels required to produce acetone in the First World War by fermentation of corn- and potato-starch (see DISCOVERY, 1944, Vol. 5, p. 370). Subsequent bio-synthetic processes for citric, gluconic and itaconic acids confirmed its value where sensitive living organisms are handled.

The number of uses of aluminium in commercial food handling is too great to give in detail. It is simpler to give some idea of the metal's limitations particularly as they affect the domestic user. Aluminium retains its bright surface owing to the presence of a thin oxide film, which is healed by oxidation in the air after the surface has been scratched and metal exposed. This film is inert to the attack of most chemical substances met in food preparation. An exception is the combination of salt and vinegar which does not allow its use in the manufacture of some types of sauces. (We have, out of curiosity, tried this mixture for cleaning aluminium saucepans, but it seemed to have hardly any effect; the result did not compare with that obtained by stewing rhubarb, which always leaves the pans with a very bright surface.) Sugar syrups also give trouble in industry but not in the home.

The reason for this is the longer resting period after cleaning which household pots have. This allows the oxide film to build up before the next time for using. The moral is to clean pans without undue delay. Food residues cover up the metal from the 'healing' effect of air so that gradual corrosion of metal underneath takes place.

What cleaning materials should be used? There are two absolute prohibitions. *Washing soda* and *caustic soda* must not be used on aluminium in any circumstances. Hot or cold, in strong or weak solutions, they will punch holes in the stoutest pans. Soapy water should be used for lightly soiled articles; most of the well-known scouring powders with steel wool will clean off the more troublesome deposits satisfactorily. Coarse scourers are to be avoided as they scratch the metal leaving crevices to which air cannot penetrate. Copper ones are dangerous because they leave particles of copper embedded, which in conjunction with aluminium form the equivalent of a battery cell and lead to electrolytic corrosion. Household 'bleaches' which do not give a guarantee that they are harmless to aluminium should be shunned as there are many cheapjack lines of bottled sodium hypochlorite on the market which flourish owing to soap rationing.

An unsatisfactory feature is the sticking of food to aluminium frying pans. The old cast iron pan does a clean job whereas the aluminium one has the infuriating habit of tearing fried eggs in half. Some improvement with old age occurs but there seems no way of giving an artificial patina to new pans. Perhaps one of the chromating or anodising processes might help—or chromium-plating, which is now possible.

The idea that the number of stomach-aches is on the increase because aluminium cooking vessels are more commonly used than ever can be discounted. Anyone who thinks that such pains can be blamed on aluminium pots and pans might ponder on the fact that if he takes pains of this sort to the doctor he will like as not be prescribed aluminium hydroxide!

Hope for Hay Fever

DURING the last decade, and more particularly during the last few years, chemists and pharmacologists have succeeded in evolving a number of synthetic organic substances which have the power to counteract the effects of histamine on body tissues. To understand the potential value of these interesting substances in medical treatment and research it is necessary to say a little about histamine and its possible role in pathological processes.

Histamine is a simple base derived, by loss of carbon dioxide, from the amino-acid histidine, an essential component of all animal proteins. Nearly all tissues contain small amounts of histamine; the lungs have by far the greatest proportion, but it is also present in blood, skin, etc. The source of the histamine normally present in tissues is a puzzle which still awaits a definite solution. But since it is extremely potent it is clear that, in the normal state, histamine must be 'bound' in tissues in some way that prevents it exerting any effect.

Few pharmacologically active agents affect such a wide range of tissues as histamine, and the administration of small amounts of it to man or animals produces a number of characteristic symptoms. The most important of these are constriction of the smaller air passages (bronchioles) in the lungs, strong contraction of the intestines and dilatation of capillaries and arterioles. The last of these effects, which is far the most important of the three effects mentioned, results in deep flushing of the skin and a large fall in blood pressure. In the dilated condition the capillaries are abnormally permeable to the fluid part of the blood (plasma), so that it leaks out into surrounding tissues and reduces the volume of circulating fluid; in extreme cases this may lead to heart failure. Unless the dose has been very large recovery takes place in a few hours. The effect of histamine on capillaries and arterioles may be observed without risk or discomfort by injecting a drop of a very dilute solution into the skin. Immediately after the injection the area surrounding it becomes reddened due to the dilatation already mentioned and then quickly changes to a white wheal as the plasma leaks into the tissues. In a sensitive individual this reaction may be provoked by less than a hundredth of a microgram (a microgram is a millionth of a grain) of histamine. The whole effect is very similar to that of a nettle sting, and indeed it has been shown that nettle stings do contain histamine (DISCOVERY, April 1948, pp. 102–3.) In the lungs the constriction of the bronchioles makes breathing difficult.

Before the advent of specific anti-histamine compounds many medical research workers, impressed by the similarity between the symptoms produced by histamine and those seen in certain pathological conditions, had come to the conclusion that, in some circumstances, the 'bound' histamine of tissues became released either locally or generally. Such conditions are seen in 'shock' following severe accidents, and in asthma, hay fever and nettle rash (*urticaria*). The stimulus which results in release of histamine may be physical damage to tissues by crushing, burning or scalding or the more subtle response of tissues to foreign substances to which they have become sensitised (allergy). The administration of anti-histamine compounds to patients with these complaints has not only proved the theory to be correct, at least in the majority of cases, but has also provided a means of treatment of these conditions.

The first substances to be found with the power to antagonise histamine were examined by D. Bovet and A. M. Staub at the Institut Pasteur in Paris in 1937; and had been synthesised, for other research purposes, by E. Fourneau. These compounds had only a feeble effect but it was nevertheless sufficient, in view of the possible importance of such compounds, to start a train of intensive research. A very large number of anti-histamine compounds have now been synthesised and tested. Their chemical structures are surprisingly diverse; for example, one is built up from the nucleus of the dye methylene blue while another is closely related to histamine itself. Of the compounds so far tried, three are at present on the market and in general use in this country*. In the treatment of many conditions, particularly those of allergic origin, they have been strikingly successful, but in asthma the success has been only partial although many sufferers have derived some benefit.

A number of new and more powerful anti-histamine substances are being examined at the present time but have not yet been made generally available. One of these is not only able to protect guinea pigs against more than one thousand lethal doses of histamine but to exert a considerable effect for several days following a single dose. It may well be that these newer compounds will succeed in cases where the earlier ones have failed.

It should perhaps be emphasised that these compounds do not destroy histamine nor do they prevent, so far as it is known at present, its liberation from the bound state in tissues; their action is solely that of preventing it exerting characteristic effects. They do nevertheless, in cases where they are successful, relieve the symptoms until a natural cure has taken place.

A final point of interest in connexion with these substances is that many, if not all, are potent local anaesthetics, some of them being almost the equal of cocaine in this respect.

To the physician the anti-histamine drugs represent one of the major therapeutic advances of the last few

* The proprietary names of these three substances are: Benadryl, Antihisan (which is chemically very similar to Neoantergan) and Histostab (chemically the same as Antistine). In the United States, Pyribenzamine is much used; this is chemically related to Antihisan. A fourth substance, the most powerful anti-histamine compound yet discovered, is 3277 R.P. (Rhone-Poulenc), which is at present undergoing clinical trials in France and Britain.

years; to the medical research worker they are tools of the utmost value in the elucidation of the mechanisms of normal and pathological processes.

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How Science Advances

MOST people probably imagine that science advances like a steam roller, cracking its problems one by one with even and inexorable force. That simple view is true only of the lower grades of activity. Rather, science advances as though by the pulling out of a drawer which gives on one side only to jam on the other. There is then nothing to be gained except by pulling on the other side. If you pull on the same side, the jamming gets even worse. Three-quarters of all kinds of research work consists in pulling on the wrong side with this very result. And the reason is simple: the same man cannot usually pull on both sides of the drawer. Another man is needed, a competitor, an upstart, an impudent fellow who probably despises the first man and who, profiting by his work, will not hesitate quickly to take the whole credit for the result of the little pull he has had the luck to give at the end.—*Dr. C. D. Darlington, F.R.S., in his Conway Memorial Lecture on 'The Conflict of Science and Society', just published by Watts and Co., London.*

New Methods of Chromatography

AMONG the most intractable of all the substances with which the inorganic chemist has to deal are the group of elements known as the 'rare earth metals'. These metals were called 'rare' because of their scarcity, but now many of them are known to occur in considerable quantities although widely dispersed in the earth's crust. The rare earth elements, fifteen in number, are quite ordinary looking metals, the names of which (e.g. europium, praseodymium and samarium) are, however, scarcely known except to the specialist. They have some practical importance: gas mantles contain compounds of cerium, and the 'flints' of petrol lighters contain lanthanum, cerium and other metals which are obtained as by-products of thorium manufacture. Some compounds of the rare earth elements are colourless and uninteresting to look at, but others are beautifully coloured; for example, salts of praseodymium are green, of europium a delicate rose and of neodymium a reddish violet.

To the chemist the interesting—and very troublesome—property of these metals is that they, and their compounds, so closely resemble each other that ordinary methods of separation fail completely. Physicists discovered the reason for this similarity years ago. It is that the outside shells of the atoms of all the elements—the layers upon which nearly all their chemical properties depend—are almost identical and all the differences are tucked away right inside the atom. This explanation gave little satisfaction to chemists struggling to prepare the various metals and their compounds in the pure state, for it gave them no hint of new methods by which they could reach their goal.

Two examples illustrate the extreme difficulty of the separation. For many years didymium was regarded as a pure metal, but in 1885 Auer von Welsbach, during a search for new materials for making gas mantles, discovered that it was really a mixture of two metals—praseodymium and neodymium. When the French chemist, Urbain, finally succeeded in separating lutecium from ytterbium in 1906, he had crystallised salts of the metals no less than 15,000 times.

Because of the great difficulty of separating these metals—even partial purification may take months or even years—their chemistry is still comparatively little known. It is, therefore, rather astonishing to find that by the application of a new technique the worst of the practical difficulties seem to have disappeared almost overnight.

The new technique was first suggested for the separation of the rare earths in 1937, but preliminary attempts were not very successful. However, more recently, very considerable effort was put into solving the problem by the Americans as part of the plutonium project. (For security reasons the results were only made public a few months ago, in the *Journal of the American Chemical Society*, 1947, Vol. 69, No. 11.) In connexion with this project it was necessary to isolate the major atomic fission products in pure form and in quantities sufficient for detailed physical, chemical and biological investigations. This presented an immediate difficulty for many of the products were isotopes of the rare earth metals whose separation had proved a stumbling-block for so many years.

The method which has proved so successful is a modification of chromatography (see DISCOVERY, April, 1945), first discovered by the Russian botanist Tswett in 1906 and used by him to separate leaf pigments, which has since been shown to be one of the most versatile methods of chemical analysis. By using columns packed with substances called 'ion exchange resins'—substances similar in action to those used in modern water-softening apparatus—many of the rare earths may be separated in a completely pure state relatively quickly and easily.

In principle, the method is this; a solution containing salts of the different metals is allowed to filter through a column packed with the resin. In this way the metals replace the hydrogen atoms of the acidic groups on the ion exchanger and are held (absorbed) on the resin. Next a solution of citric acid, to which ammonia has been added, is allowed to percolate slowly down the column and the liquid is collected in successive parts or fractions as it runs out at the bottom. The solution taken from the bottom differs from that put in at the top and each successive fraction is different in composition from the preceding fraction, i.e., some fractions are richer in one of the metals than others, which in turn contain more of a second element and so on. In some fractions, only one metal is present and this in a state of complete purity. Under ideal conditions, which, however, so far have not been obtained, every fraction will contain only one metal and there will be a sharp separation between one fraction

containing, say, only neodymium and the next containing only praseodymium and so on.

The reason for this separation is that there is in progress a continual competition between the resin and the citric acid for possession of the metal ions, the extent of removal by the citric acid varying from cerium at one end of the scale to lutecium at the other. The conditions are very critical; the composition of the citric acid solution, for instance, has to be adjusted very carefully. As an example of the magnitude of the operation, the Americans, using a set of 24 columns each 8 ft. long and 4 in. in diameter, put through a solution containing 50 grams (about 2 ounces) of a very impure neodymium salt and obtained 25 grams of completely pure material by using 250 gallons of citric acid solution over a period of one or two months. Two pounds of neodymium oxide have been obtained by this method with a purity of over 99 9%. This technique, although still not easy for large quantities, is a very great advance on older methods.

This type of chromatography may effect most remarkable purifications. Thus a specimen of erbium which the spectroscope—one of the most sensitive of analytical instruments—indicated to be absolutely pure, was shown by chromatography to contain 10 parts per million of thulium.

Incidentally, the example we have given indicates the importance of the part which analytical chemists have to play in modern atomic work. These experts in the fine art of chemical analysis are now in greater demand than ever; indeed, the availability of highly skilled analytical chemists has to be ranked as a limiting factor when considering the rate of development to be expected in the atomic field.

Ion-exchange chromatography seems to have great possibilities quite apart from the investigation of the rare earth metals. Many other metals can easily be separated from impurities mixed with them, even on an industrial scale. Thus zirconium, a rather uncommon metal which is used in the making of special steels, furnace linings, radio valves, ceramics and for many other purposes, may be obtained free from its usual contaminants by a simple chromatographic method. Chromium salts, too, can easily be purified by chromatography. The separation and purification of acids can also be effected by means of resins similar to those used for the metals.

Credit Line

MR. L. J. F. BRIMBLE, joint editor of *Nature*, contributes to the latest issue of the *Bulletin of the Atomic Scientists* an article on the exposition of science to the general public in which he refers to popular science journals and makes this comment, "In Britain there are very few, *Discovery* being far and away the best."

Could we live on Tablets?

CARTOONISTS love to picture the family consternation when little Willy in the future days of tablet meals suddenly grabs and swallows in one mouthful the entire family's Christmas dinner. Tablet meals are in fact looked forward to by some, and the thought of them is abhorred by others.

Let us knock the cartoonist's imagining on the head at once by giving some facts. The average person needs between 2500 and 3000 calories a day to keep in normal health. The most concentrated food we can get is pure fat. Pure fat supplies 4200 calories per pound, therefore even if one ate pure fat, the total weight of pills to be consumed each day is around the region of three-quarters of a pound. But, quite apart from rationing, one could not cope with anything approaching as much fat as three-quarters of a pound daily without eating other things as well. Apart from the continuous nausea of a fat diet, the body cannot burn up fat completely without the presence of an appreciable amount of carbohydrate. The products of partially 'burnt-up' fat are toxic to the body so you would not live long if you only had fat to eat. The body also requires protein—in the young to provide new tissue, in the adult to replace broken-down protein. Pure fat contains no protein. Pure fat is also entirely lacking in water-soluble vitamins such as vitamin B complex and vitamin C, though presumably these could be added in the form of an emulsion. Fat also contains no minerals and no roughage. So to our pure fat we will have to add protein, carbohydrate and roughage. Both pure protein and pure carbohydrate have a calorie value of 1860 calories per pound which is less than half that of fat. Roughage has no calorie value at all. Therefore the total weight of food which needs to be consumed per day to provide the necessary calories could not be reduced much below 1½ pounds. A pound and a half of 'pills' would take some swallowing. Tablet meals can therefore be regarded as impracticable, and in any case they are probably undesirable from the psychological and physiological points of view.

A surprising amount of the food we normally eat is water. Bread, for example, contains nearly 40% water, cakes about 60%, biscuits 5–10%; the water content of meat exceeds 60%, while the figure for fish may be as high as 85%, and 90% or more of the weight of vegetables represents water. Obviously if water is removed from foods their bulk can be very considerably reduced. Hence during the war we saw the large-scale use of dried egg, the import of which resulted in enormous saving of shipping space. Dehydrated vegetables were also used but not as extensively as one might have expected. Dehydrated fish and meat were also produced, and the dehydrated mashed potato powder now on sale in the shops is a direct result of war-time research. Military operational rations, where bulk and weight were important factors, tended to be made up of dehydrated foods and/or food with a high fat content. In some cases such as the 'emergency rations' the daily allowance was meant not to supply the day's calorie requirement but to keep a soldier going should he be cut off from normal food supplies for a day or two.

These emergency rations usually provided about 1200 calories a day; on the other hand 'operational rations', which were meant to sustain a man for perhaps one or two weeks of continuous fighting, had a high calorie value. The Australian 'Pacific' ration, which was the best operational ration of the war, supplied over 4000 calories a day. It was made up of fatty biscuits, concentrated sugar preparations and so on. Although these rations give sufficient calories and vitamins, they rapidly become boring. Our final conclusion is that dietetically fish and chips and meat and two veg. take a lot of beating.

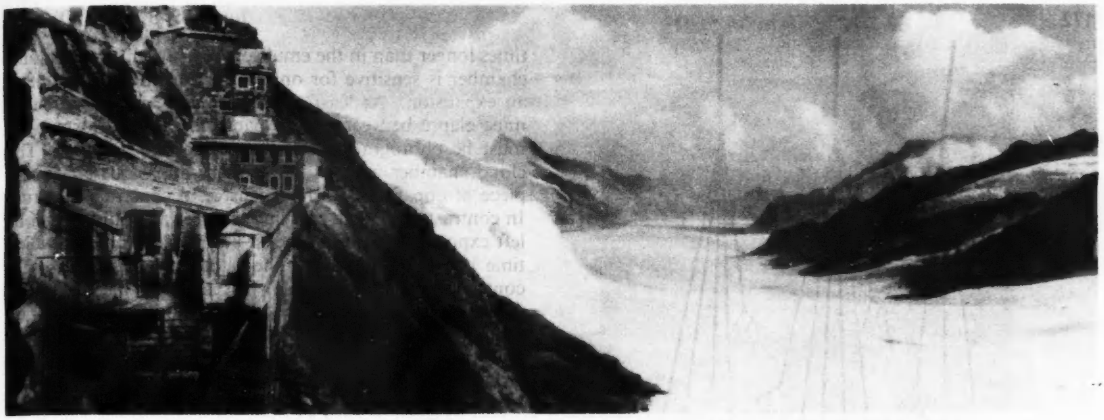


FIG. 1.—Much cosmic ray research is done at high altitudes. This is the station at Jungfraujoch, 12,000 feet high in the Alps, where a British team led by Dr. Paul George has been studying cosmic rays. Their apparatus includes an ionisation chamber weighing three tons, batteries of Geiger counters and numerous mice for an experiment to determine whether cosmic rays influence the induction of cancer by certain chemical agents.

New Fundamental Particles

COSMIC RAYS AID RESEARCH IN MANY FIELDS

MALCOLM McCAIG, Ph.D., F.Inst.P.

THE general picture of the nature of cosmic rays given in a previous DISCOVERY article* is still valid. Primary positively charged particles, almost certainly protons (nuclei of hydrogen atoms), enter the atmosphere, and before penetrating very far each proton collides with the nucleus of an atom of the air. The atom usually disintegrates, and among other things a number of mesons are produced. Mesons may have a positive or negative electric charge and have a mass greater than an electron but less than a proton. They have a greater power of penetrating matter than either electrons or protons, and it is mainly mesons that are responsible for cosmic rays penetrating down to sea level. The primary protons are almost certainly accompanied by other radiations such as positive and negative electrons and very energetic packets of waves known as photons, but all these radiations are absorbed in the upper atmosphere. Such easily absorbed components are said to be 'soft'. Although mesons can penetrate matter very efficiently they are unstable and disintegrate spontaneously after about two-millionths of a second. For this reason it is certain that mesons are not the primary particles, since their lifetime is not long enough for them to travel much more than the thickness of the atmosphere.

At sea level many kinds of radiation besides mesons can be detected in abundance. By spontaneous decay, as well as by a variety of interactions with matter, mesons can give rise to high-energy electrons and photons. Sometimes these secondary electrons or photons are able to multiply by a chain reaction so that a shower comprising an enormous number of particles results. The general picture of the whole process is illustrated in Fig. 2. Even under several hundred feet of earth (as in a mine) the mesons are accompanied by electrons and photons.

The chief additions to our knowledge of cosmic rays in the last four years have been concerned with mesons. It now appears that there are more than one kind of particle with mass intermediate between that of a proton and electron. In this article the current British practice of calling all such particles mesons will be followed. In the U.S.A. the name mesotron is still usually preferred, although even there the shorter title is gaining a foothold. (Perhaps when the characteristics of the various mesons have been firmly established, both titles will find a use.)

Not only are there mesons with different masses, and different life periods, but the processes by which mesons can react with matter are more complicated than was originally believed. Before going into more details of these new fundamental particles, a few words about experimental technique are needed to make the problem clearer.

The four methods of investigating cosmic rays involve the use of the ionisation chamber, the Geiger counter, the Wilson cloud chamber and the photographic plate respectively. The ionisation chamber measures the total intensity of cosmic rays, but is gradually being superseded by batteries of Geiger counters (see Fig. 7). These arrays of counters can be made less susceptible to the influence of spurious radioactivity and can give much more detailed information about the nature of the cosmic rays. The most important recent development of technique is connected with the photographic emulsion method.† In consequence of improvements in special photographic emulsions, some of the most important results, particularly

* DISCOVERY, p. 136, May 1944.

† An article on Photographic Plates in Nuclear Research by R. H. Herz appeared in DISCOVERY, March 1947, p. 73.

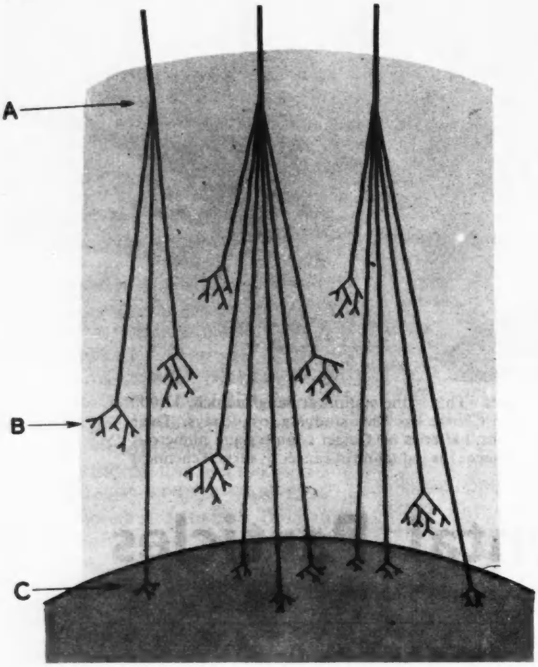


FIG. 2.—Passage of cosmic rays through the atmosphere. *A*, primary protons produce groups of mesons in the upper atmosphere at a height of 16 kilometres or more. *B*, some mesons decay or collide with atoms of the air causing extensive showers of electrons and photons. *C*, the remaining mesons are absorbed in the earth's crust; showers, similar to those produced in the atmosphere but more localised, result.

those relating to mesons, have been obtained. The photographic technique is complementary to the cloud chamber, which it in no way supersedes.

In the cloud chamber a charged particle leaves a trail of ions (charged atoms) on which water or alcohol vapour can condense. A trail of mist indicating the path of the charged particle is thereby produced. In the photographic emulsion, a charged particle leaves a trail of sensitised grains. When the emulsion is developed, these grains are reduced to metallic silver as in the ordinary photographic process.

The thickest emulsion that can be successfully developed is about a fifth of a millimetre, and the thickness generally used is only a quarter of this. This limit to the thickness of the emulsion imposes certain restrictions on the use of the method. The longest tracks made by particles in the emulsion before finally passing into the air or glass are about a millimetre in length. With such a short length of track it is not possible at present to determine the momentum of the particle by measuring the curvature of the track in a magnetic field. On the other hand the material of the emulsion is much more dense than the gas of the cloud chamber. The particle encounters far more atoms in the emulsion than it would in the cloud chamber, and is more likely to promote an atomic disintegration, or be brought to rest at the end of its range in the emulsion, even though the track in the chamber may be a thousand times longer than in the emulsion. Furthermore, the cloud chamber is sensitive for only a fraction of a second after an expansion. At least several seconds and often longer must elapse between each expansion, and each expansion must be photographed on a separate plate or film. The cloud chamber with all its auxiliary apparatus is a bulky piece of apparatus, fairly expensive to construct and run. In contrast, one plate carrying the special emulsion can be left exposed for several weeks, during the whole of which time it will be sensitive. The photographic plate is very convenient in inaccessible places and this technique enables observations to be made at high altitudes—on mountain tops, and from balloons and aeroplanes. Since many cosmic ray processes occur much more frequently at high altitudes, several cosmic ray research stations have been built on mountain tops. One situated in the Alps is shown in Fig. 1.

Three kinds of Mesons?

The kind of data which enables the mass of a charged particle to be measured includes the curvature of its path in a magnetic field; its range before finally coming to rest; the number of ions produced (in a cloud chamber), or the number of developable grains in a photographic emulsion; and the distribution of these ions or developable grains along the track. Normally at least two of these characteristics must be measured before the mass can be calculated, while none of the methods can be applied if the momentum of the particle is very great. Thus the mass of the meson has been measured for only a small and unrepresentative selection of particles. Until recently these measurements suggested a value for the mass of the meson about 200 times that of an electron, although individual measurements varied from 39 to 560. (Expressed in terms of these electron-mass units the mass of the proton is about 1800.)

Dr. C. M. G. Lattes, Dr. G. S. P. Occhialini and Dr. C. F. Powell have published a number of photographs showing the disintegration of a particle of mass about 400 into one of about half this mass, presumably an ordinary meson. One such photograph is shown in Fig. 3. (This figure was obtained by magnifying the tracks in a photographic emulsion with a microscope, and taking a number of photomicrographs, each covering a very small area of emulsion. These pictures were then carefully fitted together to form the mosaic seen in this illustration.) Normally the absolute determination of the mass of a particle from its track in an emulsion is very inaccurate. The ratio of the masses of two particles in the same emulsion can, however, be determined more accurately, and there can be no doubt that in this photograph we have two mesons one of which is about twice as heavy as the other. The track of the new particle makes a considerable angle with the primary particle. In order to maintain the conservation of momentum a third particle must be involved in the process. There are theoretical reasons for believing that this third particle is a neutral meson although the possibility that it is a photon has been considered.

The old view about the decay of the meson was that the products of the decay were an electron and a neutrino. (The neutrino is a light neutral particle, almost impossible

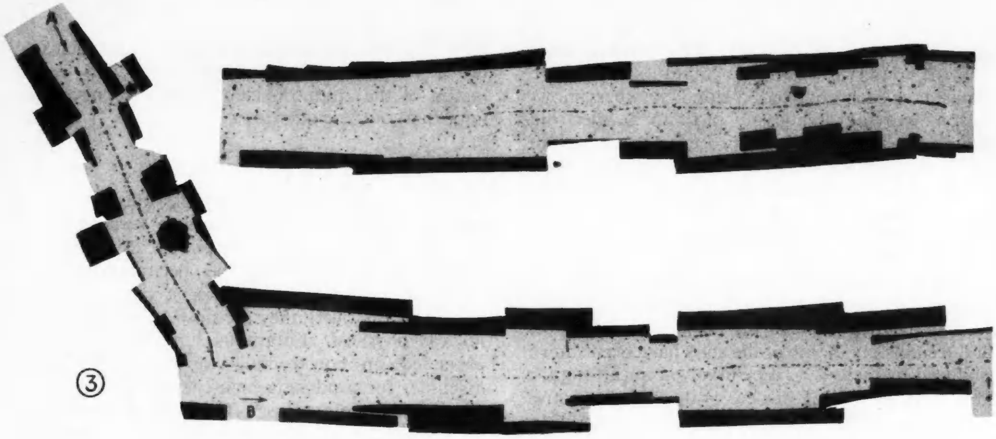
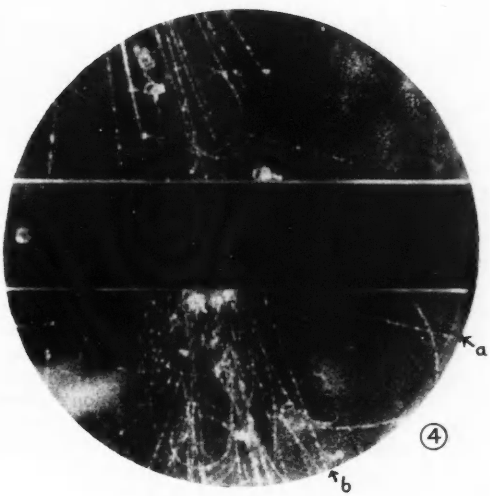
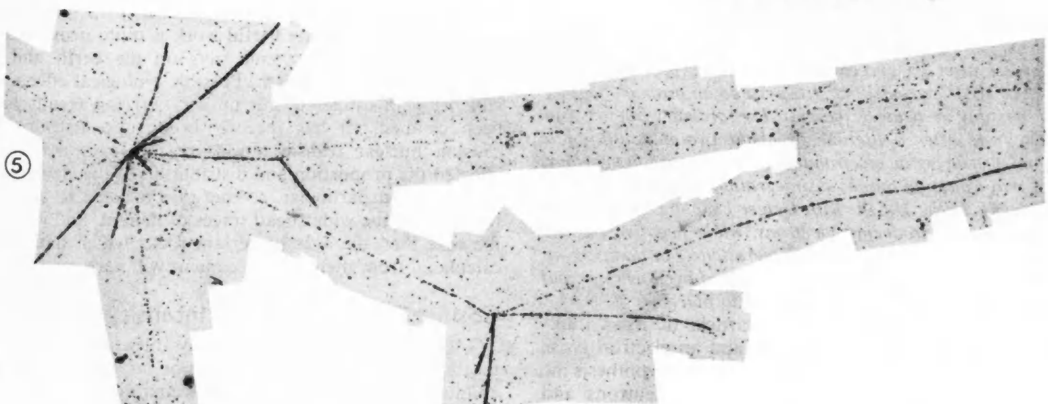


FIG. 3.—Decay of a heavy meson with the production of a light meson. The thick track A is due to a heavy meson. This decays, giving rise to a light meson track B, with a sudden change in direction. The track of the light meson is continued in the inset at the top. (*Dr. C. M. G. Lattes, Dr. G. S. P. Occhialini, and Dr. C. F. Powell, "Nature", October 4, 1947; by permission of the Editors.*)

FIG. 4.—Evidence for new neutral particle. The forked tracks a and b are believed to be mesons produced by the decay of a neutral particle of mass about 1000. The photographs were taken in a magnetic field, and from the slight curvature produced in the tracks the momenta and signs of the particles can be deduced. (*Dr. G. D. Rochester and Dr. C. C. Butler, "Nature", December 20, 1947, by permission of the Editors.*)

FIG. 5.—Atomic disintegrations. The larger star is due to an atomic disintegration in which mesons and protons were produced. One of these mesons caused a second disintegration shown by the smaller star. (*Dr. Lattes, Dr. Occhialini, and Dr. Powell, "Nature", October 11, 1947, by permission of the Editors.*)





to detect, but whose existence has been assumed in order to preserve the conservation of momentum.) Four or five photographs have been obtained in cloud chambers showing a meson decaying and giving birth to an electron. These photographs prove that this process does occur, but they still leave open the question of whether this is the only process by which a meson can decay. A number of experiments made in the United States with Geiger counters suggest that this process accounts for the end of about half the mesons.

In photographic emulsions stars such as that shown in Fig. 5 are frequently observed, and each of these stars represents the disintegration of the nucleus of one of the atoms in the emulsion. Some of the stars have been shown to be produced by mesons. To be involved in causing the disintegration of an atomic nucleus is thus an alternative fate for a meson. That such disintegration should be observed in the dense medium of an emulsion, while spontaneous decay should be observed in the rarer gas of a cloud chamber, is to be expected.

Dr. G. D. Rochester and Dr. C. C. Butler have recently published cloud chamber photographs from which they deduce the existence of heavy neutral mesons. Their apparatus is shown in Fig. 6. The forked track in Fig. 4 is believed to be produced by such a neutral particle of mass about 1000. The argument to support the hypothesis runs like this. The forked track must involve a third particle in order to preserve the conservation of momentum, and this particle must have passed through a lead plate, which crosses the middle of the cloud chamber. The third particle cannot be charged, otherwise it would leave a track; on the other hand it cannot be a photon, because it is known that a photon would have set up a shower of electrons in the lead plate. The third particle is therefore neutral, and its mass is calculated from the masses and momenta of the particles *a* and *b*. These workers have also published photographs showing the formation of a neutral particle of about this mass. There is also reference in a recent Russian paper to a particle "intermediate between the meson and proton", and some French scientists claim to have detected a charged particle of mass about 900.

To sum up, we now have evidence of charged mesons of at least two different masses. The heavier particle disintegrates after an exceedingly short time (probably about 10^{-10} *or* 10^{-11} *seconds) and gives rise to an ordinary meson, and possibly a neutral meson. The ordinary meson can disintegrate after a lifetime of about two-millionths of a second, producing an electron and, it is supposed, a neutrino, or it may cause an atomic disintegration. There is evidence from work in the U.S.A. with Geiger counters that positive mesons decay, producing electrons, while negative mesons are more likely to produce disintegrations. In addition we have the heavier neutral particles, claimed by Rochester and Butler, which are somewhat difficult to place.*

The original prediction of a particle of mass intermediate between that of a proton and an electron arose from a theory of the atomic nucleus. In this hypothesis the mesons play a part in binding together neutrons and protons in a nucleus, which may be compared with the role of electrons in holding together the atoms in a chemical molecule. Naturally the discovery of mesons in cosmic rays was hailed as a vindication of this theory; the discovery of the different kinds of mesons naturally raises many important and rather perplexing problems. Which of the cosmic ray mesons (if any) can be identified with the meson of the atomic nucleus is clearly one of the most important of these questions.

Mesons Artificially Produced

Four years ago it was possible only to suggest that cosmic ray research might in time lead to information which could prove of practical value. Since that time the release of atomic energy has been accomplished, and although cosmic rays appear to have played but a minor part in its discovery they are now an accepted tool of the nuclear physicist. Enormous sums of money are being expended on constructing various types of electrical machines for producing high-energy particles with which to bombard the nucleus.* The large (184-inch) cyclotron at Berkeley, California, is the most powerful of these machines so far in operation. With the aid of this cyclotron Dr. Gardner and Dr. C. M. G. Lattes have just produced mesons artificially, that is, without the aid of cosmic rays. (Dr. Lattes spent two years in England recently, and was one of the co-authors of the photographic emulsion pictures shown in Figs. 3 and 5.) This is a most important, although not entirely unexpected development, which is considered likely to stimulate both nuclear and cosmic ray research. The artificial mesons are, of course, of very low energy compared with those found in cosmic rays. Even the machines that are planned for accelerating particles to still higher speeds are never likely to produce anything so energetic as cosmic rays. The difficulty about employing cosmic rays as a research tool is that they cannot be turned on just where and when they are required; nevertheless, they are bound to retain an important place in nuclear research in consequence of their unique properties.

In view of the high energy of the individual cosmic ray particles people are sometimes surprised that there is no possibility of harnessing cosmic rays themselves. Although the individual cosmic ray particles have much higher energies even than any particle in an atomic bomb, the number of cosmic rays falling on any area is relatively very small, and the total amount of energy compared with that required to do any useful work is quite insignificant. The direct effect of cosmic rays on the earth and its inhabitants is in fact small. Possible biological effects are still being investigated, but no very striking results have been claimed. It has recently been suggested that by causing nuclear transmutations cosmic rays may have affected the proportion and distribution of the elements in the earth. In particular, cosmic rays may be responsible for some of the widespread traces of helium, and if this is the case then the ages of certain rocks which have been calculated from their helium content will need revision.

Cosmic Rays fluctuate in Intensity

The measurement of cosmic ray intensity, whether by means of an ionisation chamber or an array of Geiger counters, is rather analogous to estimating the intensity of a rainstorm by exposing a flat tray and counting the number of drops that fall upon it in a given time. In the first place the result is influenced by what is known as statistical

* A short account of such machines appeared in DISCOVERY, November, 1947, p. 323.

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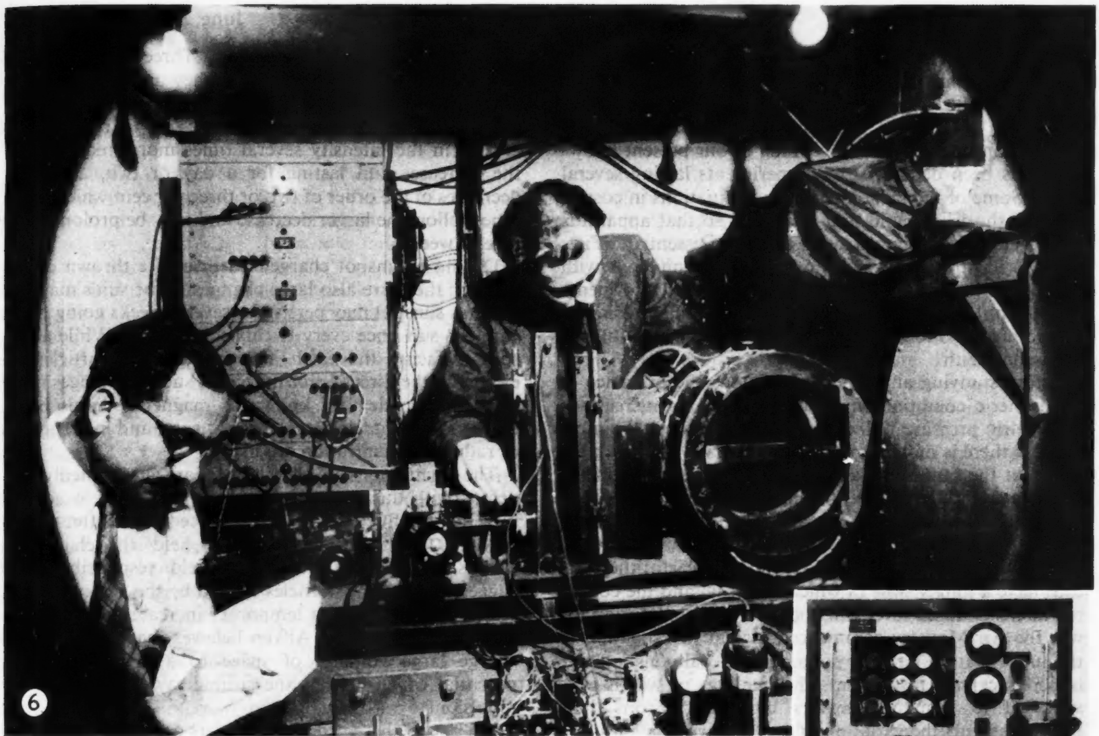
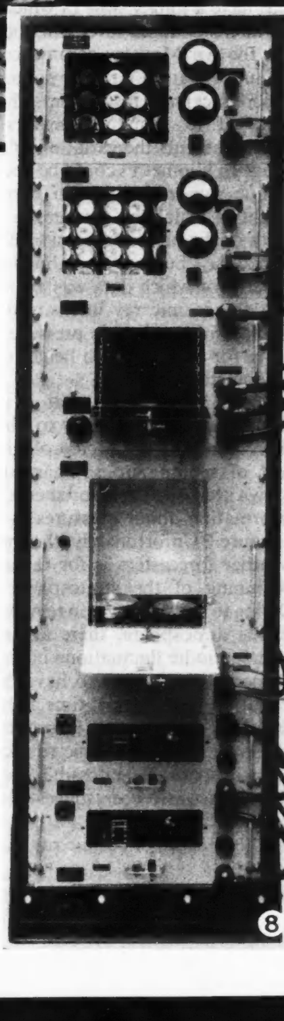


FIG. 6.—Dr. Butler adjusting the cloud chamber with which heavy neutral mesons have been detected.

FIGS. 7 and 8.—Cosmic-ray counting apparatus made by Cinema Television for Manchester University. FIG. 7.—Interior view of the unit containing trays of Geiger-Muller counters; there are two of these units. FIG. 8.—The rest of the apparatus. From the top downwards are two electronic scaling circuits, the camera, the barometer, clock, and mechanical counters which are photographed once an hour, and two power packs.



fluctuation, which means that the result may be greater or less through sheer chance, without any variation in the true rate. The way to reduce errors due to statistical fluctuation is to use a very large counting area or take observations for a long time. Much of our present knowledge has been deduced from experiments lasting several years. Some of the most interesting fluctuations in cosmic rays are short-lived and non-recurrent, so that apparatus with a large counting area has become essential. Figs. 7 and 8 illustrate a cosmic ray recording unit built with that object in view for Manchester University by Cinema Television, Ltd. It is planned to build a number of similar but improved models for use in various parts of the Commonwealth.

Before studying any other fluctuations the influence of atmospheric conditions must be known. An increase in barometric pressure reduces cosmic ray intensity, simply because there is more air above the observer to absorb the rays. At the same time an increase of pressure or of the mean temperature of the atmosphere raises the height of the level at which the mesons are produced. Referring to Fig. 1, it can readily be seen that the mesons will have to traverse a longer path before reaching the earth; they will thus have a longer time in which to decay, and the cosmic ray intensity at sea level will, therefore, be less. During the war the Air Ministry commenced regular investigation of the upper atmosphere by unmanned balloons. These balloons carried instruments the readings of which were signalled to ground observers by radio. From these balloon ascents the variation of pressure with height up to about 16 kilometres could be deduced. Duperier correlated cosmic ray intensity with barometric pressure and the height at which the pressure is 100 millibars (about one-tenth of the pressure at sea level). This height varies from day to day, but averages about 16 kilometres, and was the highest for which data was available. The final results are that the cosmic ray intensity decreases by 2·28% for an increase in barometric pressure of one centimetre and by 5·4% for an increase in height of the 100-millibar layer of 1 kilometre.

It had been hoped that it would be possible to use cosmic ray measurements to obtain data about the upper air required by the Meteorological Office, and so save the cost of sending up so many balloons. Experience has shown that such measurements yield sufficiently accurate information about pressures at a height of 16 kilometres or more. Unfortunately, the information required by the weather forecasters is for rather lower heights up to the beginning of the stratosphere at about 10 kilometres. Owing to daily changes in temperature and tidal movements in the atmosphere, there are naturally 24-hour and 12-hour periodic fluctuations in the intensity of cosmic rays. Duperier also claims to have discovered a small periodic variation with sidereal time. This variation can only be of the order of 0·2% but is important as it would indicate a preponderance of cosmic rays coming from certain directions in space. The possibility of a small component from the sun has also been suggested: but the results are not yet conclusive.

The changes in cosmic ray activity which are associated with sunspots are very peculiar. Three main types of fluctuation have been observed. They are large increases in the intensity sometimes of the order of 15–20%, but usually lasting for only an hour or so. Fairly large decreases in the intensity several times more frequent than the increases and lasting for a day or two, and small decreases of the order of two or three per cent which sometimes follow the larger decrease and may be prolonged for several weeks.

During a sunspot charged particles are thrown out by the sun; there are also large changes in the sun's magnetic field. A sunspot may persist for several weeks going round with the sun once every twenty-seven days. While a sunspot is facing the earth and the charged particles are ejected in the direction of the earth, sudden changes in the earth's magnetic field known as magnetic storms occur. At the same time displays of the aurora, and interruptions of radio communication are likely.

The fluctuations in cosmic rays are undoubtedly connected with this general phenomenon, but the exact way in which the fluctuations are produced is a matter of controversy. Different writers have held the changes in earth's or the sun's magnetic field responsible. The suggestion that the particles ejected by the sun may themselves be recorded as a temporary increase in cosmic rays has been made, while Alfvén believes that these particles charge large volumes of space to a high electrostatic potential which deflects the cosmic rays by attraction or repulsion.

No one of these processes appears capable of explaining all the observed fluctuations. The complicated fluctuations observed suggest that several causes are operating simultaneously.

Origin of Cosmic Rays

The ultimate origin of cosmic rays is still wrapt in mystery. If they come from the stars the emissive power of the sun is strangely small. The light reaching the earth from the stars is negligible compared with that from the sun, but even if some cosmic rays do come from the sun, and this is not yet certain, they must be a very small fraction of the whole. The most interesting theory that has been put forward is from that versatile scientist, J. B. S. Haldane. He has suggested that if the universe is expanding it must have been very small at one time. Under these circumstances many novel processes might have been possible. For instance, the planets of the solar system might have emitted radiation by 'quantum jumps' like the electrons of an atom. This radiation might have been moving about the universe as cosmic rays ever since. Let us hasten to add that Haldane himself would be the last to claim that this should be treated as more than a speculation to be investigated. Without taking the quantum jumps of the planets too seriously, the suggestion that cosmic rays are part of the universe, and have existed for a very long time, is perhaps the most satisfactory answer that has yet been put forward, even if it does only shelve the problem of how the rays were produced.

The Kruger National Park

DAVID S. EVANS, M.A., Ph.D.

A RELIEF model of the southern tip of Africa presents an extraordinary appearance. Round the coast is a belt of low-lying land not more than a couple of hundred miles wide. At its inward edge the whole land is suddenly elevated to form a vast plateau. The surface of this plateau is slightly inclined and its elevation increases from round about three thousand feet in the south-west to more than five thousand feet towards its north-eastern parts which include the two provinces of the Orange Free State and the Transvaal. The upward tilt towards its eastern edge culminates in the high mountains of the Drakensberg range, which at its northern end separates the Transvaal from Natal.

The surface of the plateau is rolling and is dotted with innumerable hills, all having the characteristic African shape of a flat top to which the surrounding land rises in a smooth sweep ending in a cliff. To the south-west the country is arid and stony, but in the north-east its surface, known as the high veld, is covered with immense tracts of grassland. At the highest part of the plateau stands Africa's principal industrial region, the Rand, with the city of Johannesburg and its satellite towns of the Reef. To the north the land falls again, broken by a number of ranges of considerable hills, to the low-lying valley of the Limpopo which forms the boundary of Southern Rhodesia. These lower-lying regions constitute the low veld or bush veld and are covered with low trees, bush and tall grass.

The high veld has practically no permanent rivers, and those which do exist will usually in the dry season degenerate into a string of rocky pools. Although the total annual rainfall of the Transvaal high veld is as great as that in many parts of England, it is intensely seasonal and something like four-fifths or more of the annual rain comes in the summer between October and March. In the winter dry season the grass withers to a burnt brown. The low veld areas of the province to the north and east have permanent rivers and are more luxuriantly vegetated. In the days of the Republic a system of stock farming was developed in which the high veld was used for summer grazing and the bush veld for winter grazing, but the latter could not be employed throughout the year because of the prevalence of insect pests, which, breeding in the wet summer season, brought diseases to man and beast alike.

In 1898 in the days of the Transvaal Republic an area of bush country on the Portuguese East African border was set aside as a reserve for the preservation of the fauna and flora of this type of country. The buck and other animals of the high veld had been almost exterminated by hunting and it was an act of great foresight to attempt to preserve the unique fauna of Africa by setting aside an area which, in any case, was at that time so dangerous to health that it seemed unlikely ever to be useable for farming purposes. After the South African War the area was reproclaimed as a reserve and extended. Today the Kruger National Park, as it is known, comprises a strip of low-lying country on the Portuguese East African border of about 200 miles from north to south and an average width of forty miles. As a result of the foresight of the founders and its excellent organisation this park has now become one of the show places of the Union of South Africa.

It is visited annually by many thousands of people who go to see the animals of the region ranging wild in completely natural surroundings. The animals include big game such as elephant, lion, hippo, crocodile and a few buffalo as well as smaller and less dangerous animals, including buck of all kinds—impala, kudu, waterbuck, antelope, and many more. Other animals to be seen include giraffe, zebra, wildebeest, warthog, jackals and wild dog, monkeys and baboons. In addition many kinds of birds, including vultures, are plentiful. Even the characteristic vegetation of the bush country is of such a strange and almost unearthly appearance that it exercises a strong fascination. It seems almost incredible that thousands of people each year can see at quite close quarters, and without more protection than a motor car, large and dangerous animals with a complete immunity from accidents, and it is part of the skilled organisation of the park that this should be possible.

From Pretoria the park lies about 250 miles to the east, and an early start is made in the cold of the African winter dawn. For the first hundred miles the road is tarred and climbs slowly across the immense rolling grasslands of the high veld. Thereafter the tar ends, and the broad gravel road continues eastward, winding its way over downs strongly reminiscent of those of Northumberland and Cumberland. The surface is good, and with a large American-built car, calculated to withstand the hammering which it will receive before the trip is over, high speeds can be maintained. At Machadodorp some 150 miles from Pretoria the road suddenly reaches the edge of the plateau. Here it seems as if one had come to the end of the world.

(*Left*).—Lions stroll along a road in the Kruger National Park. (*Right*).—Giraffes, whose height from hoof to crown of head may reach 17–18 feet (so the description of 'skyscrapers of the veld' is apt), abound in the park.

The land appears as if cut off with a knife and the plateau breaks up into a number of huge mountainous fingers stretching out into the country ahead. The road plunges down, turning and twisting into the valleys. Even more astonishing as an engineering feat is the construction of the railway which also begins to descend sharply here, dropping nearly 4,000 feet in about seventy track miles.

This line, which runs alongside the road for much of the way from Pretoria, is the historic line of the Portuguese port of Delagoa Bay, intended to provide an outlet to the east for the Transvaal Republic. It zigzags across the mountain faces and loops in and out of tunnels in most astonishing fashion. The gauge is the standard three feet six inches of southern Africa, but even on so narrow a track the big multicoupled locomotives haul loads, in particular of coal from the nearby Witbank Collieries, which would not disgrace the broader gauge of Europe.

The well-watered valley floor below is only the first step in the descent to the level of the reserve, but even this first drop in altitude takes us into an entirely new country. Here streams flow down the valleys, trees abound; the grass at the roadside reaches higher than the roof of the car. Sub-tropical fruits such as the pawpaw grow in the gardens of the rather rare homesteads by the roadside. Fifty miles further on is the little town of Nelspruit, which lies at the head of the final descent to the altitude of the Park only two thousand feet or less above the sea. At dawn on the high veld we may have been shivering, but down at this level in the blazing sun we begin to remember that we are only a little way outside the tropics, and layers of clothing begin to come off.

We intend to enter the Park at Malelane at a point about half-way along its southern end, and our road carries along the banks of the Crocodile River and out into more open country, from which we can see, towering behind, the mountains from which we have descended. Eventually turning off the wide gravelled road which leads on to Lourenço Marques we take a typical African secondary road—a narrow winding strip of earth and stones which might be almost impassable in wet weather, and reach the gates of the Park. Here we pay a small fee for each member of the party and receive an illustrated book with pictures of the animals and instructions as to our conduct in the Reserve. If we feel a certain trepidation at the thought of encountering African elephants—reputed to be aggressive and dangerous—wandering about unrestrained, we do our best to conceal it. The rules are simple enough: the most important being that, come what may, one must remain in the car. Lion, it appears, have never been hunted from cars in the Reserve, and do not associate them with their natural enemy, Man. Even so, the intelligence that lion sleeping in the road may be persuaded to move by driving slowly up to them in a determined manner looks almost like carrying things too far. We learn that we may carry one weapon which must be sealed by the authorities and due explanation given if the seal is broken. The only other instruction is that we must be in camp by dark.

Our expectations of meeting all conceivable big game at once are disappointed during the short drive into camp. Privately one views the five-foot wire fence which surrounds the camp as a rather slight protection against any animal which really wished to enter, but a day or so in the park is enough to demonstrate the fact that with abundant natural game available the temptations of a human diet are quite negligible and that the animals are quite as anxious to be left alone as we are to leave them in peace.

Memories of camping holidays of the past chiefly consist of slight discomfort borne with rather exaggerated cheerfulness, and the very high level of comfort in the camps in the Park is a most pleasant surprise. One sleeps in a proper bed in the type of circular stone hut roofed with thatch—a more permanent version of a native hut—known as a rondavel. Cooking is done out of doors on a huge wood fire, and, to crown all, hot baths may be had.

Beyond the camp fences the Reserve stretches: a rolling country of twisted grey trees through which run narrow winding earth or gravel roads. In wet weather the country must be almost impassable for the roads are intersected by many dry water courses or dongas with very steep sides. Even in dry weather these must be negotiated with care and the car must be taken through at a speed nicely judged to enable it to climb out at the far side, but not so fast that

(*Left*).—Zebras and Wildebeest. The zebra encountered in the park is the Chapman sub-species of the common Burchell Zebra, which is gregarious and often seen in company with wildebeest. The Blue Wildebeest is the most numerous of the larger antelopes in the park. (*Right*).—Hippopotami are found in all the principal rivers in the park.

the bottom of the car will bump down on the ground and suffer damage. Even so, carelessly driven cars do quite often suffer damage and have to be towed to one of the camps with garage facilities where a mechanic performs prodigies of repair work with means which seem quite inadequate to some of the major tasks which he undertakes.

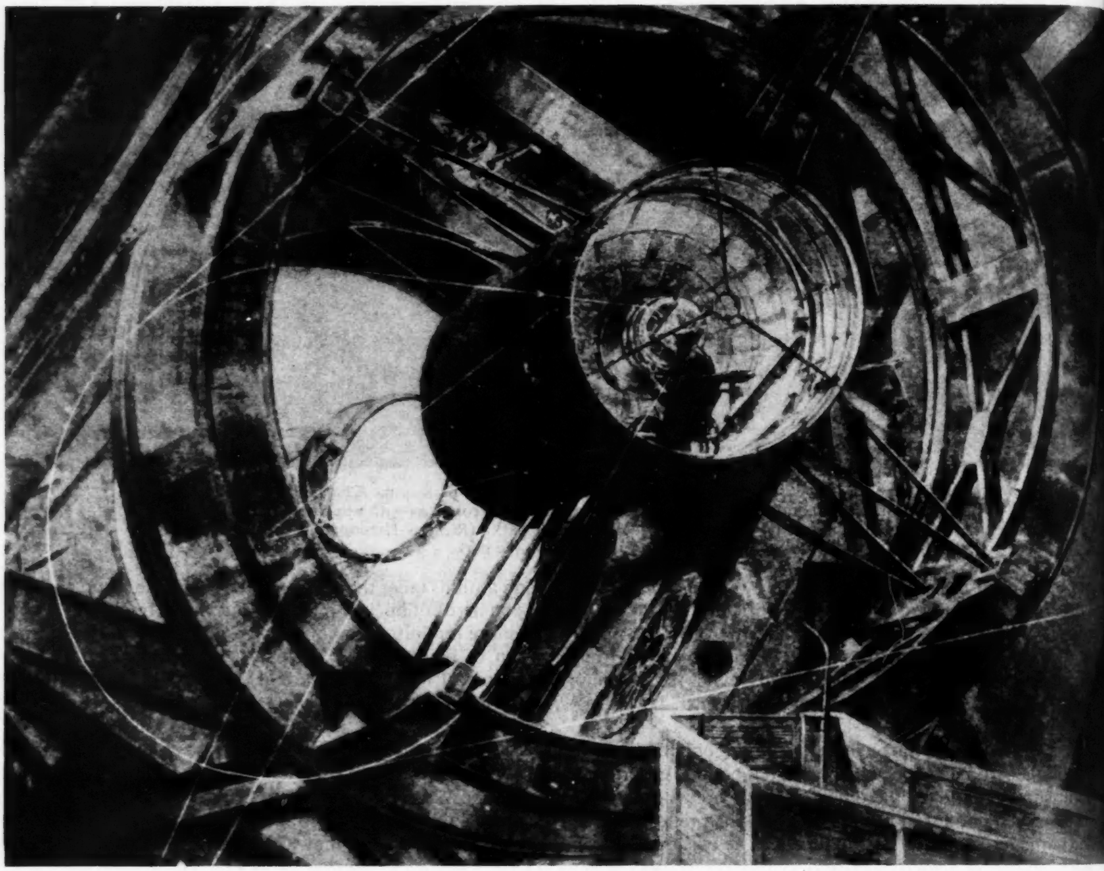
One drives slowly through the bush, not only because of the danger from unexpected dongas, but because experience soon shows that even the official limit of twenty-five miles an hour is a good deal too fast to allow the eye to pick out the game in its natural surroundings. The twisted horns of buck mimic exactly the gnarled branches of the trees. The rounded brown backs of impala look like the boulders scattered here and there in the bush. In the strong sunlight the bright markings of zebra fade into the background in the most astonishing way. Even a large animal such as a giraffe, whose bold skin markings match the play of sunlight to perfection, can be passed within a few yards and be almost missed. The trees and bushes limit visibility often to a few yards beyond which they emerge into a grey-brown tangle against which even elephant may be hard to see. Many of the animals 'freeze' on the approach of the car but seem to have little fear. Irritatingly enough for the photographer, already exasperated by the effectiveness of natural camouflage, as soon as the car slows down, most of the animals drift quietly away and put a bush or two between themselves and the unwelcome visitor. Even elephant, whose presence somewhere about is amply evidenced by trees torn out by the roots, and huge piles of droppings, keep their distance. It is said that elephant have a range of distinct vision of only about fifty yards, and that only closer than this is the animal likely to charge. One is warned not to approach too closely or to try to pass them, and a sight of them in natural surroundings, when they look, as all the animals do, very much larger than in zoos, is enough to discourage any inclination to rashness.

It is a strange and unforgettable experience to drive through this weird landscape of distorted trees on which occasionally vultures may be roosting, with tangled bushes and anthills taller than a man, every now and again coming upon herds of buck in numbers and with a frequency which is more reminiscent of a Hollywood 'bring 'em back alive' than of reality. What at first sight seems deserted bush will reveal itself to the careful eye, especially in the early morning, as teeming with birds, monkeys and baboons, and here and there a small tribe of the fantastically ugly warthog may be seen lolloping at an ungainly trot away from the road. A close view of giraffe feeding from the tree tops strains all one's powers of belief, and as they canter away holding their necks stiffly at the same angle it seems impossible that any process of evolution could have produced so curious a beast.

A number of fairly considerable rivers run through the Reserve and many of the camps are on their banks. FISHING NOT ALLOWED notices are here replaced by the sterner: BEWARE OF CROCODILE, and one may catch a glimpse of the nose of a hippo which disappears and reappears every minute or two as the animal comes up to breathe. There are in addition a number of pools which are the favourite haunts of these animals, and there one may leave the car and scramble over rocks to a suitable point of vantage, scaring foot-long lizards from their sunbaths in the process. At first all one sees are the sand bars, rocky pools and reeds of the dry-season African river, but presently one of the rocks heaves itself out of the water and sinks back in leisurely fashion, and one realises that here is another example of camouflage and that that mass of rocks is a herd of twenty or thirty hippo wallowing comfortably in a pool.

One cannot visit the park without being tremendously impressed with the sights which it has to offer, and with the scenic beauty, not only of the place itself but of its surroundings. To reach it one passes through mountain scenery of a vast magnificence, after which anything might seem a disappointment, only to find that this is but the prelude to a truly dramatic climax.

(The four photographs are reproduced by permission of South African Railways and Harbours. The photograph of Zebra and Wildebeest is copyright by C. P. de L. Beyers.)



The 200-inch Reflector at Mount Palomar

M. DAVIDSON, D.Sc., F.R.A.S.

THE 200-inch reflector of the Mount Palomar Observatory, which is situated approximately south-east of Los Angeles, north-east of San Diego, is being brought into action this year, and there are many people who would like to know some details about this giant telescope which, it is hoped, will settle certain problems that still await solution in various branches of astronomy.

The 100-inch reflecting telescope made its début at Mount Wilson early in 1918 and before it was in use many years it was realised that it asked more questions than it could answer and that a larger instrument was essential if many intractable problems were to be solved. "Like buried treasures, the outposts of the Universe have beckoned to the adventurous from immemorial times. Princes and potentates, political or industrial, equally with men of science, have felt the lure of the uncharted seas of space." So wrote George Ellery Hale early in 1928, and he asked whether it would not be possible to advance to an aperture of 200 inches, or better still, of twenty-five feet. Five years before he wrote these words, Hale had resigned the directorship of Mount Wilson Observatory and had dreamed of greater achievements than the 100-inch, but he lived to see his dream only partly realised: he died in 1938 before the figuring of the Palomar mirror was completed.

Was it possible to make a 200-inch mirror from a glass block which, to secure the necessary rigidity, must be at least thirty inches thick and would weigh about 40 tons? How could the unequal expansion and contraction of such a huge block be overcome and distortion of stellar images be avoided? To obviate such difficulties trials were made of quartz which has a much lower coefficient of expansion than glass, and experiments showed that quartz dust blown through the flame of a torch worked for smaller mirrors—up to discs about 2 feet in diameter. When the method was tried out on much larger discs the practical difficulties were too great and after the General Electric Company had spent $600,000 on experiments it was decided early in 1932 to try another material, pyrex.

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Fig. 2 (r gram sho penetratir 200-inch housed in observator sea level. C. Ives, published

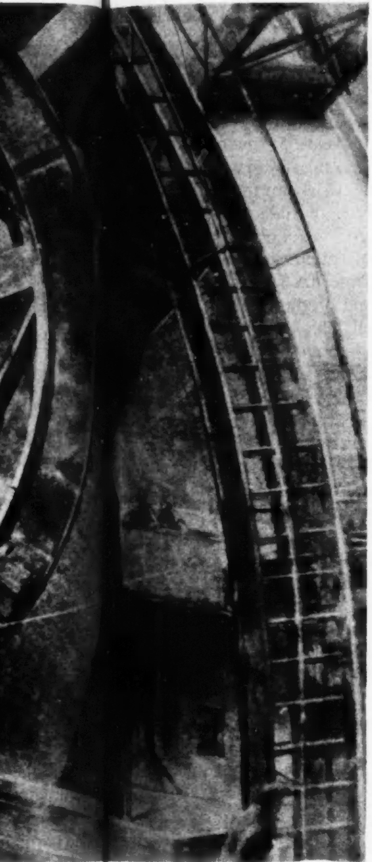

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Fig. 1 (top).—Star's eye view of the giant telescope in action. (Drawing by Russell Porter, from "The Glass Giant of Polomar".)

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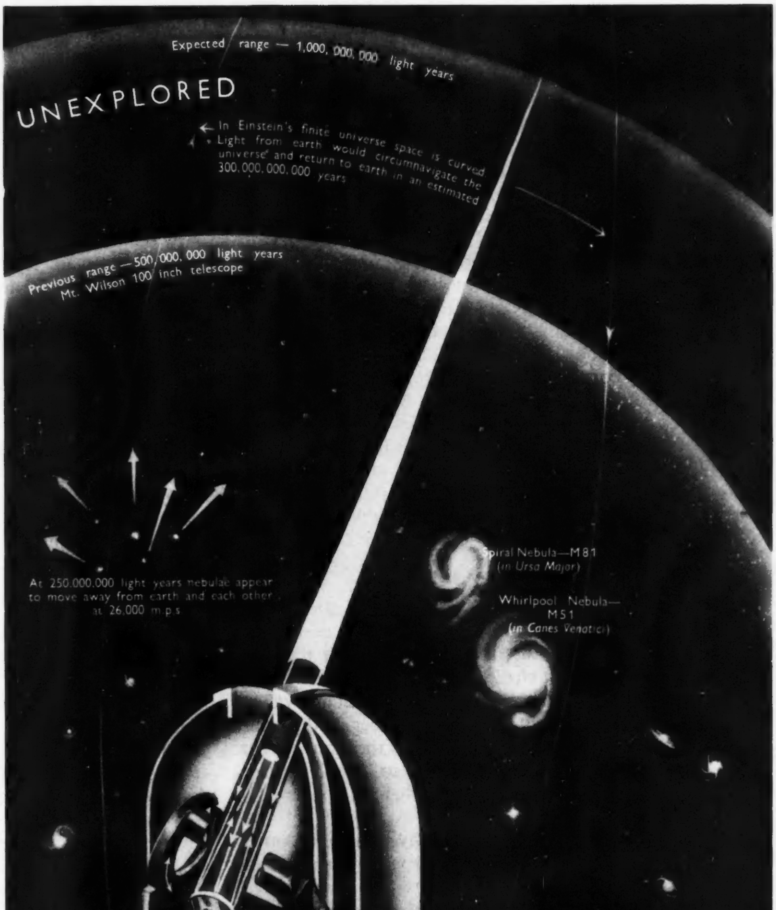
Fig. 2 (right).—This diagram shows the enormous penetrating power of the 200-inch reflector which is housed in the mountain-top observatory 5000 feet above sea level. (Drawing by W. C. Ives, based on a figure published in "Time".)



Although the coefficient of expansion of pyrex is greater than that of quartz, it is considerably less than that of glass, and after many conferences and discussions the Corning Glass Works undertook to cast a 200-inch disc with a thin face supported on a ribbed back, this being produced by cores arranged around the bottom of the mould, like the petals of a flower. This arrangement eliminated 20 tons of glass, reducing the weight of the disc from 40 to 20 tons.

It would take too long to describe the difficulties and disappointments encountered in the work.* The low-expansion pyrex refused to behave in large quantities, although it could be cast into small discs; the molten glass, which had to be poured out by ladles, congealed before it could flow round the corners between the cores; time after time the cores broke loose and floated on the glass; one disc which was cast perfectly cracked a few days later; but finally, after many efforts and alterations in the technique, a 120-inch disc was cast and came out of the annealer quite perfect. McCauley, who was in charge of disc making, calculated that its time for cooling would be four months—a calculation which was verified by subsequent tests. Using the same method he found that the 200-inch would require ten months to cool, and this time was given to the giant disc when it was cast. In spite of all the precautions taken and modifications made to the design the cores broke loose when the first attempt to cast the 200-inch was made on March 25, 1934. A special cooling system was then installed to keep the interior of every core below dangerous temperature. On December 2, 1934, the disc was successfully cast, and now forms the giant mirror for the 200-inch telescope. It was left to 'soak' for two months at a steady temperature and then to cool evenly for eight additional months.

A sudden flood by the Chemung River in midsummer nearly undid all the long and careful work on the disc, and it was only by superhuman efforts that it was saved from destruction. The following February when the disc was packed in its steel casing and ready to be sent to Pasadena for figuring, the Chemung inundated the countryside. A corner of the factory, which obstructed the way along which they were slowly moving their precious disc, had to be demolished to save it from destruction. Forty-eight hours later the scene of these operations disappeared under the river! On March 26, 1936, the disc started on its 3000 miles' journey to Pasadena and arrived safely after an adventurous trip. For four years it became the personal responsibility of Marcus H. Brown, formerly an assistant to his father on his ranch, then a helper to a cable splicer, errand-boy in a packing-house, day labourer and truck-driver. He taught himself how to make small mirrors and then larger ones—but it is a long story—and it will suffice to say that he was responsible for training a team who worked with him, and after four years 5 tons of glass had been removed from the disc in making its surface spherical. This is a very difficult piece of work and requires great patience and skill—even with small reflectors. All that now remained was to smooth up the spherical surface and deepen it into a paraboloid, after which came the polishing. Subsequent tests showed that internal strains were insignificant—contrary to at least one prediction.

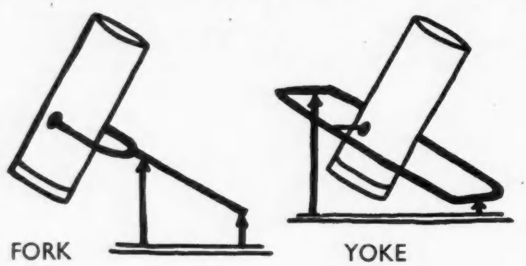


FIG. 3.—The two main types of telescope mounting. (From *The Glass Giant of Palomar*.)

Captain Clyde S. McDowell was lent by the United States Navy to take charge of the engineering operations connected with the telescope, and these presented a number of formidable difficulties. The moving parts of the telescope weigh 450 tons, and it was essential that friction at the bearings should be reduced to a minimum. After considering different methods it was decided that oil could be forced in between the horseshoe (of which more later) and its cradle so that the telescope would actually float clear of its bearings. The film of oil on which the horseshoe really floats, is the thickness of thin tissue paper. Oil forced in under a pressure of 250 lb. gave ideal results—incomparably better than those which could have been obtained with the best roller- or ball-bearings made.

The telescope tube (or its skeleton, to be more correct) was designed to hold the mirror in any desired position in mid-air, then 60 feet away, at its focal point, a 6-foot cage full of mirrors and instruments and carrying an observer—several tons in all—and at no time to allow the two elements to slip out of line with each other more than 0·8 inch. A very rigid hollow square was used for the centre section of the tube and two equally rigid rings for the ends. These three were tied together by stiff diagonal beams forming eight triangles, the base of each triangle being on a side of the square and its apex on a ring. The bearings on which the tube swings are held in the two opposite sides of the square centre section and things were so adjusted that the mirror, held in one ring, would just balance the observer and his equipment, held in the other. The design allowed the mirror and the observer's cage to move together in the same direction and by the same amount, so that the differential flexure is very small.

The 100-inch telescope mount is of the 'yoke' type in which the tube is hung between two sloping beams joined at both ends and carried in bearings at the joints. This type does not allow the telescope to be used for observing objects in the vicinity of the pole of the heavens or, in other words, near the pole star in the northern hemisphere, and it was decided to use the 'fork' type for the 200-inch, but a firm which was given the contract to build the whole instrument broke the contract because it could not guarantee the rigidity of any fork that could be built. Finally a compromise was reached by the use of a horseshoe bearing 46 feet in diameter and 4 feet thick, weighing over 150 tons (up to that time this was the largest bearing that

* Readers who want a detailed account which, besides including all the scientific aspects of the subject, deals also with the human factor, providing a most fascinating story of the difficulties which were overcome by the vision, perseverance and indomitable courage of the few who refused to accept defeat, should read *The Glass Giant of Palomar*, by David O. Woodbury (Heinemann, London and Toronto, 1940).

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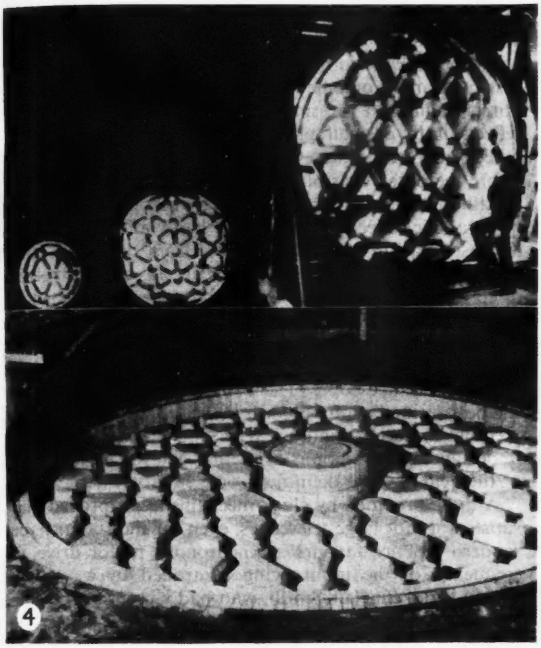


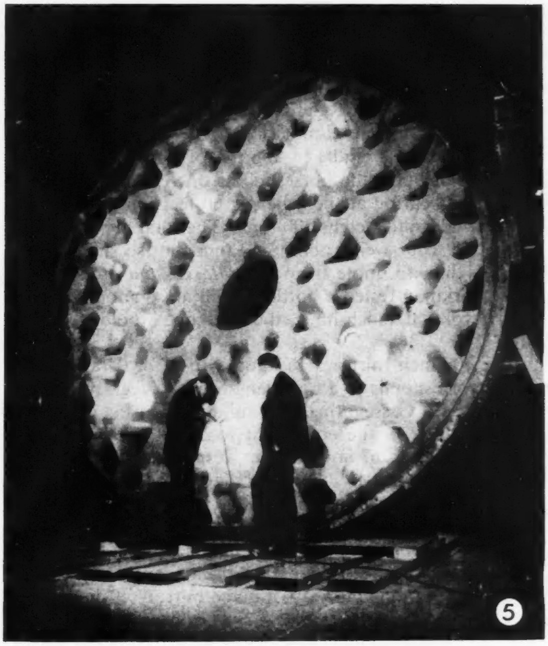
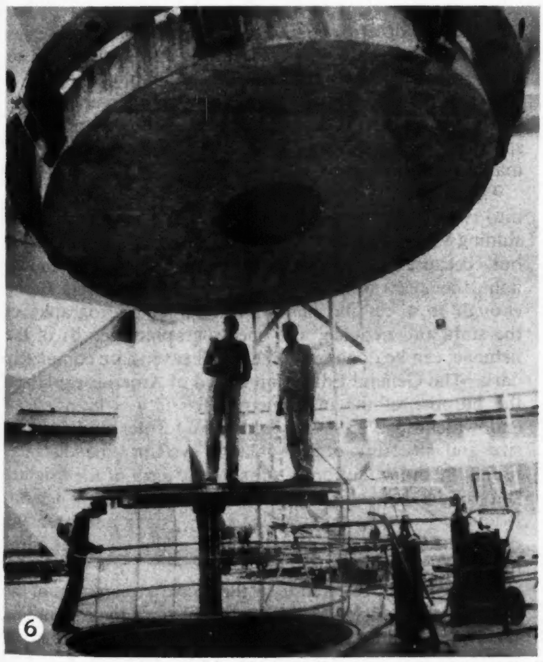


FIG. 4.—Huge mirrors are not to be bought from a catalogue. The Palomar mirror was produced only after much experimenting. (*Above*) 30-inch, 60-inch and 120-inch discs were cast before a start could be made on the first mould (*below*) for the 200-inch disc. FIG. 5.—McCauley and Hostetter test the ribs at the back of the successful 200-inch disc. (From *The Glass Giant of Palomar*.)



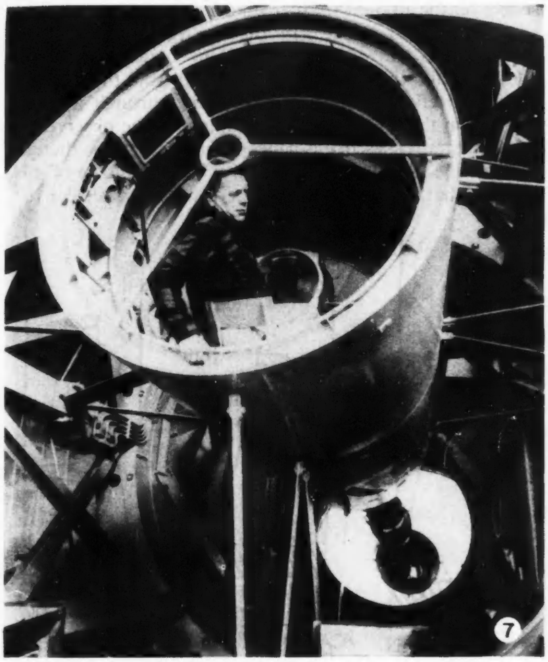


FIG. 6.—The 200-inch disc was cast in 1934. Grinding and polishing was not completed until 1947, when the mirror was pronounced perfect to within a millionth of an inch. In the meantime the telescope was tested, using this dummy mirror made of concrete. FIG. 7.—The mirror in position (February 1948). It appears here as a circular white area (*lower right*) in which the photo-cage is seen reflected.

the hand of man had ever attempted), made in three pieces and then bolted together. This enormous bearing enables the telescope, which can lie in the throat of the horseshoe, to point directly to the north pole of the heavens, if required to do so. Reference has already been made to the almost complete elimination of friction between the horseshoe and its cradle by the use of a film of oil. The yoke which holds the horseshoe at one end and a cross-beam and bearing at the other, is 60 feet long and about 50 feet wide, and weighs 300 tons. The total moving parts of the telescope weigh about 450 tons, but so small is the friction that, to quote from *The Glass Giant of Palomar*, "If a workman rested a bottle of milk on one of the arms of the yoke at lunch-hour, the telescope would begin to turn."

The 200-inch mirror was figured to a focal ratio $f/3{\cdot}3$ which corresponds to a focal length of $51\frac{1}{2}$ feet, but it can be used as a Cassegrain, working at $f/16$ or as a Coudé, working at $f/30$, the equivalent focal lengths in the last two cases being 267 and 500 feet, respectively. (This focal ratio is obtained by dividing the focal length by the diameter of the mirror.) The difference between the three types just referred to is explained in Fig. 8.

In the *Newtonian* reflector the light from a star or other heavenly body is reflected towards the open end of the telescope and falls on a small plane mirror set diagonally so that the light is reflected at right-angles to its original direction. The image is then viewed with an eyepiece which magnifies to any convenient amount—several hundred times in many cases. Although the diagonal mirror intercepts some of the light entering the open end of the telescope, yet the amount so intercepted is so small as to be of very little consequence. In the *Cassegrain* telescope a small convex mirror is placed at the upper end of the telescope, and the light reflected on to it from the concave mirror is reflected back again, passing through a small opening in the centre of the large mirror. The observer in the Cassegrain telescope is beneath this mirror, and though this may be somewhat inconvenient, one advantage of this form is that by adjusting the curve of the small convex mirror, the focal length of the telescope can be made longer without lengthening the instrument itself.

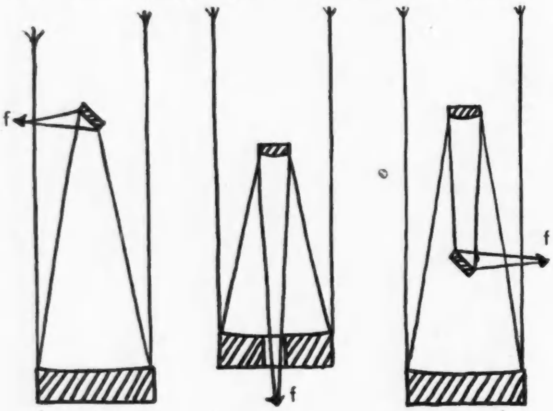


FIG. 8.—Three common arrangements for the reflecting telescope. The Palomar telescope can be used as a Newtonian, Cassegrain or Coudé reflector. (From *The Glass Giant of Palomar*.)

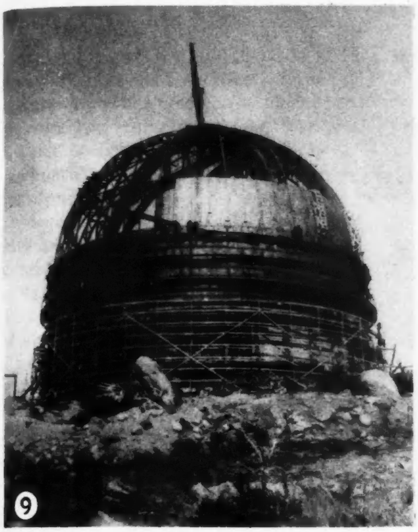
In the *Coudé* form, the Newtonian and Cassegrain systems are combined, the light from the large mirror falling on the small convex mirror which in turn reflects it to a small plane mirror set diagonally. This reflects it towards the eyepiece on the right of the figure where the observer is placed.

Although chromatic and spherical aberrations are absent in parabolic reflectors, images are badly affected by coma and astigmatism at small distances from the axis. These defects impose severe restrictions in all cases involving direct photography, but a correcting lens, designed by Dr. Frank Ross, placed in the converging beam near the focus, will overcome the coma difficulty in parabolic reflectors. Two correcting lenses have been designed for the 200-inch telescope. The first, intended for use under the best seeing conditions, will increase tenfold the area of the field of good definition. The second, intended for use under average conditions of seeing, will increase the area of the field of good definition some twenty- or thirty-fold.

A drive provided by clock mechanism has proved quite satisfactory for large telescopes, even for the 100-inch, but modern practice favours a synchronous motor drive, the frequency of the input being controlled by a valve or tuning-fork. Sinclair Smith, who had charge of the automatic control of the 200-inch, knew that he was dying but refused to take a very necessary rest in the resolute fight to finish the job that he had started. When at last his colleagues persuaded him to go to the hospital for further treatment, it was too late. Before he could submit himself to the treatment he had died. It would be utterly impossible to describe the electrical control because, as Woodbury says, speaking of Smith's application of it to the telescope—so very technical and involved—". . . it would seem hopeless to explain it outside of an engineering meeting, and even there it would be intelligible mainly to specialists". That it will function in a highly satisfactory manner is a foregone conclusion.

The programme of the 200-inch telescope will be divided into two parts. During the two weeks when the moon is shining very extensive spectrographic work will be carried out, because the spectroscope can work during moonlight, the spectrum of the moonlit sky being rarely strong enough to affect the plates. But direct photography of the stars and nebulae, and spectrographic records of the nebulae, can be done only when the heavens are completely dark. The General Education Board of America explained the purpose of the instrument when it was granting an endowment in 1928. "It would make further studies in the size and structure of the galactic systems, the distance, radiation and evolution of stars, the spectra of the brighter stars under high dispersion; it would give much new information on the separation of binary stars, and on many other phenomena bearing directly on the constitution of matter."

One point not referred to in the above explanation of the purpose of the instrument is the problem of the Expanding Universe. Will it disprove the theory of the red shift of the spiral nebulae? If the red shift does not mean that the spiral nebulae are flying away from one another, what does it mean? Other lines of exploration are on the supernovae; also on the gravitational fields of the spiral nebulae and



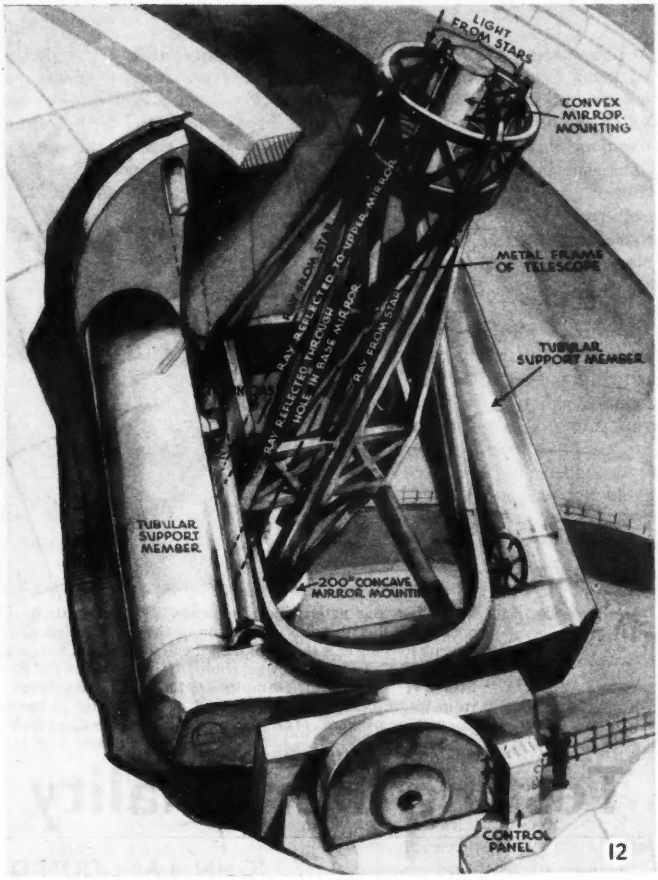
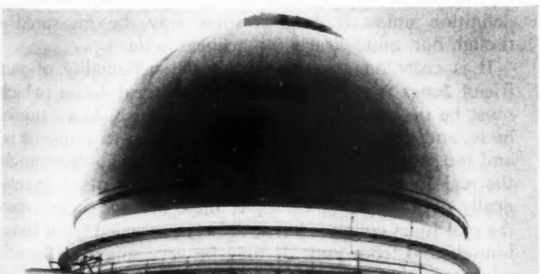
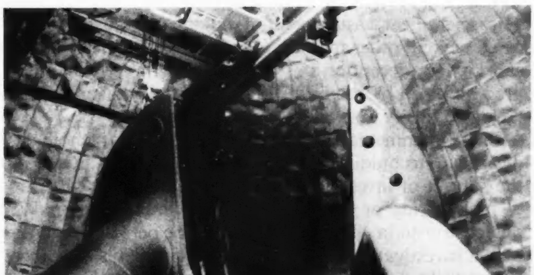


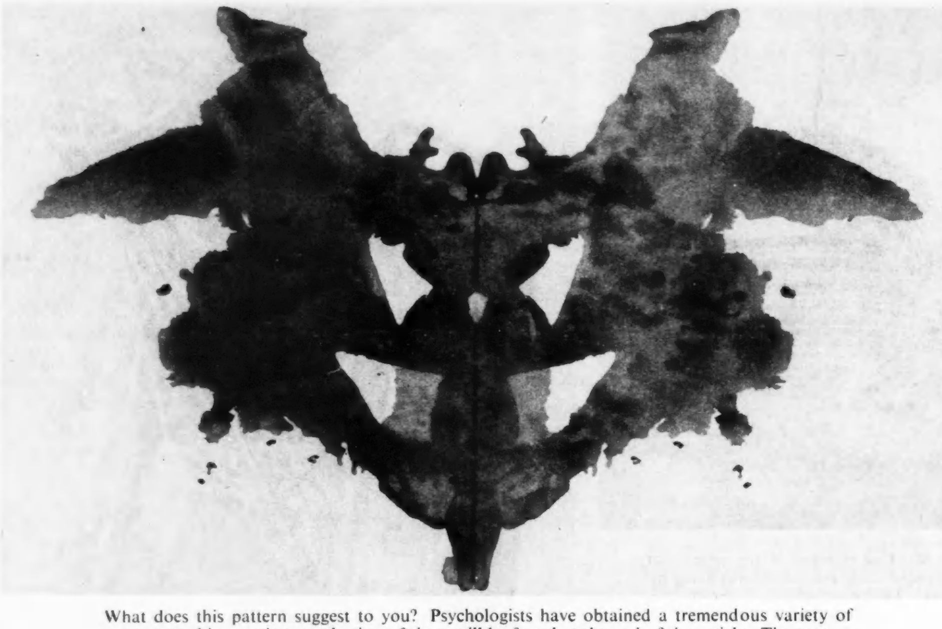
FIG. 9.—Construction of the observatory proceeded while the mirror was being prepared. This photograph, taken in 1937, shows plates being placed in position for welding on the dome of the observatory, which is 128 feet high, 135 feet in diameter. FIG. 10.—The 45-ton lower member of the yoke mounting arrives at the observatory. This picture was taken in 1938. FIG. 11.—Interior view of the observatory, showing the yoke section ready for the mirror to be installed. This stage was reached in 1939. The war brought the Palomar Project to a complete standstill; not until 1945 could work be resumed. FIG. 12.—The optical principles of the Palomar telescope are shown diagrammatically in this drawing by W. C. Ives. (*Courtesy of "The Sphere".*)





the possibility of these providing a new proof of the Theory of Relativity by their action in bending the rays of light from the very remote galaxies. Of course, it is possible that some work may be done on the planets, but it is very unlikely that much time will be wasted by using the giant telescope for this purpose.

Six million dollars were spent on the largest telescope that the world has ever seen, because its builders believed that it was justified. Perhaps this giant will also ask more questions than it can answer—like the 100-inch—and then men with vision will construct a super-giant, irrespective of expense and of obstacles incomparably greater than those encountered in the construction of the 200-inch telescope.



What does this pattern suggest to you? Psychologists have obtained a tremendous variety of answers to this question; a selection of them will be found at the end of the article. The pattern you are looking at is the inkblot on the first of a set of ten cards which form the basis of one of the most delicate tests used by psychologists. Known as the Rorschach Test, it can claim successes over a very wide field; examples are the prediction of the capacity of undergraduates to benefit from future university training, and the prediction of the way airmen will react to flight in a rarefied atmosphere. (*This illustration comes from Rorschach's "Psychodiagnostik", by permission of Hans Huber, Bern.*)

Testing Personality with Inkblots

JOHN LANGDON-DAVIES

THE scientific measurement of human nature is complicated beyond other measuring techniques by the unlimited capacity for deception possessed by the thing to be measured and also by the frequent urge in the measuring technician to falsify his results.

The fundamental qualities which any psychological measuring technique must possess are (1) an ability to put the subject of investigation off the scent so that all forms of malingering or dishonesty become impossible, and (2) objective criteria which will eliminate the personal equation of the investigator. When these two problems have been successfully tackled a third almost invariably arises, namely, to define precisely the thing which is being measured. For example, is it innate intelligence or the product of education? Is it intelligence as a whole or a specific faculty? Intelligence tests, after a long adolescence, have now reached a degree of maturity where these three problems may be considered satisfactorily solved. The measurement techniques can be shown to have validity by an appeal to the proving ground of actual daily life; the probability of success in various tasks can be foretold by means of the tests.

But there are other things which psychologists would like to measure besides intelligence. There is, for example, Personality, a concept which is clearly valid but which evades precise definition, and will continue to evade definition unless it can, in some way, be measured—though not, quite clearly, on a linear scale.

It is common experience that the personality of our friend Jones is multiple. There is the real Jones (which must be defined), there is the Jones which Jones thinks he is, and the Jones Jones would like you to think he is, and the Jones you actually do think he is. To disentangle the real Jones from the other three is very often scientifically desirable. For example, there are occasions when the real Jones contains latent defects concealed from Jones himself and from you. It may be very much to Jones's advantage that these defects be unmasked at the earliest possible moment, yet Jones will probably try to hide them from you and probably he will succeed. One of the major achievements of Professor Sigmund Freud was to show that a useful technique for unmasking the real Jones was to get the multiple Jones of everyday life to offer observations, judgments, 'free associations' upon material to which he was not likely to attach great importance. The chief starting point developed by Freud for his technique was, of course, Jones's dreams. Apart from other good reasons for the analysis of dreams was the fact that in his uninhibited comments on them Jones was unaware of any danger of giving the real Jones away.

In the same way Professor Jung used the free association method where Jones was induced to respond to apparently

innocuous words without his being given time to think about them or his responses. Jones has been given small pictures by other research workers and been encouraged to write or recite stories about them, and once more, in the act of becoming story-teller, he has been taken off his guard and has given valuable information about the real Jones.

Moreover, in everyday life we have all found ourselves idly looking at some amorphous object and constructing complicated mental pictures: Virginia Woolf wrote a story, *The Mark on the Wall*, elaborating this tendency, Polonius prompted by Hamlet found no difficulty in seeing more than a cloud in a cloud, much modern art depends for its effect on the observer supplying a rich content to the matter supplied by the artist, a B.B.C. critic echoed universal experience by saying that he preferred simple designs in railway carriages because they enabled him to imagine all sorts of things into them on a long journey.

We can assume without argument that all these creative pastimes entered upon so nonchalantly, so uncritically, are likely to catch Jones off his guard; and to lead inwards to the real Jones, so carefully hidden when, in ordinary daily life, Jones keeps his guards well up.

In the second decade of this century it occurred to a young Swiss psychologist, Herman Rorschach, that a childhood game with inkblots which most of us have played in our time could be made to satisfy the criteria of a personality test. A blot of ink is made on non-porous paper, the paper is folded across the blot and pressure applied. The result is a bilaterally symmetrical pattern. If this pattern is presented to anyone with a request for a description of what the person sees in it, a large number of different answers will be given by different people. The nature of these answers clearly indicates certain tendencies or factors in the observer's personality. If one man sees a bat, another human entrails, a third nothing and a fourth more than one image in the details of the blot, it is *a priori* probable that the differences are significant in the assessment of their several personalities.

What precisely the significance may be is, however, by no means self-evident, and it was on this problem that Rorschach spent the last ten years of his life until his death in 1922.

His first step was to standardise his inkblots. Out of thousands of folded blots ten were selected for a standard test. Five were made with black ink only and five with one or more coloured inks as well. These ten inkblots are published as a set of cards by the Swiss medical publisher Hans Huber of Bern, and are used throughout the world by Rorschach specialists for giving the test. The test is simplicity itself. The recipient is given each card in turn and asked what it represents to him. The answers, and any exclamatory asides, are recorded with details as to whether the image has been called up by the card as a whole, or by a part only of the design, and if so, precisely what part. Having gone through the ten cards and said all he feels like saying the recipient's task is done. Nobody who has not given the test a number of times will be prepared for the variety of responses which will be invoked by any one card, and the reader is invited to verify this fact for himself by trying the blot illustrating this article on himself and a few friends.

The task of interpreting the results is exceedingly complicated and in its ever increasing complexity full of controversy among the experts. The responses must be scored according to characteristics which have been shown to be diagnostically significant as a result of studying many thousands of tests. The first decision is into responses based on the whole card (*W*) and those based on some detail of the design (*D*). *W* responses are broken down into subdivisions. Thus there is a *DW* or '*confabulatory*' response *W* where, for example, the recipient sees in some small detail the head and beak of a bird and says that the whole card is a bird though the rest cannot by any stretch of imagination be fitted on to the beak and head.

There are 'organised popular' *W*s, 'superior *W* constructions', 'crude determinant' *W*s and so forth. In the same way with the *D*s, there are 'usual detail' *D*s in which the description is one usually made by most recipients, there are small details *d*, there are unusual details *Dd*, tiny details *dd*, edge details *de*, rare details *dr*, and so on. There are also *S* responses where the recipient chooses a white space enclosed by some part of the blot and bases his description on that.

In the second place, each response is put into a category based on considering how and why the recipient sees what he sees. The main divisions are into *F* responses based on static form, *M* responses where the recipient reads human movement of some sort into the blot, *C* responses where the colour is the chief suggestive factor, and these are numerously subdivided. Thirdly, classification of content has to be included—human figures, mythological figures, sexual concepts, parts of animals, animal anatomy, landscapes and maps, flowers and botanical diagrams, abstract concepts and some others are significant categories.

Enough has been said to show that a complicated scoring system expressed in symbols has been worked out as a basis for interpreting results. Experiment has shown that such things as the number of responses, or their imaginative excellence, are of only secondary importance and that the really revealing factors are such highly abstracted estimates as the relative proportion of responses stimulated by a feeling of movement and by colour considerations —that is the relative proportion of *M* responses and *C* responses, or the percentage of the total responses referring to animals or parts of animals.

When the score has been carefully analysed it will reveal to the expert information upon which he can base an estimate of at least seven trends in the personality of the recipient:

(1) The degree and mode of control with which the subject tries to regulate his experiences and actions.
(2) The responsiveness of his emotional energies to stimulations from outside and promptings from within.
(3) His mental approach to given problems and situations.
(4) His creative or imaginative capacities, and the use he makes of them.
(5) A general estimate of his intellectual level and the major qualitative features of his thinking.
(6) A general estimate of the degree of security or anxiety, of balance in general, and specific unbalances.
(7) The relative degree of maturity in the total personality development.

Estimates cannot, however, be made on a single factor in the score but are the result of balancing a number of different pieces of evidence. Thus 'originality' is not assessed on the total number of responses, nor on the fact that only a small proportion of them are those that most people are found to make. Such matters as the number of tiny details (*dd*) chosen, the parts of animals seen and many others must be given appropriate weight. The man who is naturally original can be distinguished from the one who is trying hard to be original by the fact that his score contains an undue proportion of *dd*s or of vague *W*s and so forth.

Anxiety can be assessed by a consideration of the responses to colour and to the 'shading' effects of grey and broken patches in the design and the relationship of *C* responses to *F* responses. Specific fears of death, or sex, or environment, reveal themselves after a careful weighing of many different elements in the score, together with the way in which the recipient reacts to certain cards—hesitations, exclamations, gestures.

In looking for evidence of psychological trouble or deficiency correct diagnosis has been found to result from a balanced consideration of some twenty-six factors in the score, none of which by themselves can be regarded as indicative. Thus inability to see anything in several cards, excessive use of white spaces, the percentage of *W* responses to *D* responses, too many or too few *M* responses, responses based solely on colour, a tendency to make responses in a rigid order beginning with *W* and continuing through usual *d*, unusual *d*, *dd*, *de* and so forth, interruption of flow of responses owing to suddenly seeing colour or shading, and many others, have diagnostic value, but only when balanced one against the other and added up to a sum total according to a carefully worked-out system of points.

It will at once be seen that the value of the Rorschach test depends on its being handled by experts, and whenever this is so the layman is wise to demand evidence of validity. The Rorschach test can claim diagnostic success over a very wide field. It has predicted the future academic achievement of undergraduates at matriculation with greater accuracy than intelligence tests. It has assessed accurately the reaction of schizophrenics to insulin shock. It has foretold the effect on a sample of Air Force trainees of oxygen deprivation. It has usefully classified psychotics and helped with the prognosis of their disease. It can unveil certain forms of malingering and distinguish between passing moods and underlying character.

As a test of intelligence, the Rorschach test holds a rather special position for its value does not lie in the accurate assessing of a man's I.Q. There are far better and more direct ways of doing this. What it can do is more subtle; it gives an estimate of how far a man's emotional make-up is likely to be helping or hindering his purely intellectual capacity. It is common knowledge that a high I.Q. in itself is no guarantee of intellectual success, but the Rorschach test can indicate what part other factors of personality are likely to be playing in a man's chances of using 100% of his potentialities.

The test has great theoretical value in the problem of the psychosomatic nature of disease. It has given evidence to support the theory that certain diseases are associated with specific types of personality. In one very comprehensive experiment the test was given to sufferers from rheumatic disease, cardiovascular disease, diabetes and fractures. The Rorschach expert was able to divide the patients into four categories successfully without knowing the nature of the diseases from which they suffered. One category which comprised those admitted to the hospital with fractures showed the criteria for further subdivisions, and on comparing the results with the clinical histories these subdivisions were found to have clinical validity also. Thus the test separated out the patients with 'accident proneness' from those suffering from more truly 'accidental' accidents.

It will be evident that one of the drawbacks to the Rorschach test for practical purposes is the length of time absorbed in giving it and in assessing the scores. To deal with the first, a group test has been devised in which recipients write down their responses to the inkblots depicted on lantern slides. The Group Rorschach test has been used in the Australian Air Force, in branches of the U.S. Signal Corps, in parachute units in Canada, in New York child guidance clinics and in Sing Sing Prison. It has been found that severely psychotic patients can be induced to take this group test in spite of their usually unco-operative nature.

The problem of time required for scoring has been attacked by a radically different technique called the Multiple Choice Test. The recipient is given a booklet in which a series of alternative descriptions, chosen from thousands of completed tests, is offered him. His job is to choose the description which he prefers. Scoring is based upon inferences from a very large number of replies and although it is not claimed that this method is as subtle as the original test it has been found useful, especially for military purposes.

As with intelligence tests, the U.S.A. early took the lead in research into the Rorschach Test, and in 1936 a quarterly publication, the Rorschach Research Exchange, was established to act as a clearing house for theoretical discussions and for accounts of research. Three years later a Rorschach Institute began the controlled training of experts. Especially in the U.S.A. the test has been applied in a wide variety of fields, including criminals, juvenile offenders, stutterers, alcoholics, epileptics, twins and primitive peoples, homosexuals, malingerers and all kinds of psychotic personalities. In England, interesting work has been done particularly by Professor P. E. Vernon. A recent bibliography lists 642 books and papers since 1933. Thus a vast amount of material has accumulated which has significance not merely in limited and practical fields but in the far more important realms of psychological theory. It is probably not an exaggeration to say that Herman Rorschach and his now widely famous set of ten inkblots have provided the most promising instrument for approaching some of the incommensurables of psychology.

(*What the pattern on p. 186 suggested to ten different people:* a bat, pelvis, dancer, bell, mask, waves, tonsils, coastline, dirt, spooks.)

READING LIST

H. Rorschach, *Psychodiagnostik* (English translation), 1942.

S. J. Beck, *Rorschach's Test*, 2 Vols., New York, 1944–5.

B. Klopfer and D. M. Kelley, *The Rorschach Technique*, New York, 1946.

M. R. Harrower-Erickson and M. E. Steiner, *Large-scale Rorschach Techniques*, Springfield, 1945.

Robert Hooke and the Modern Music Hall

OLD Hamish McTavish, according to a story which is very popular with our music-hall comedians, was dying in London. His son cycled post haste all the way from Aberdeen to be at his father's side. On arrival he was told that the old man's sad condition was the result of just one thing—he was dying for want of a breath of good Scottish air. Thereupon young McTavish, with typical Gaelic resourcefulness, fetched his bicycle up from the street and let the air out of the tyres. But alas, the old man expired —for young McTavish had forgotten that he'd pumped up his tyres at Doncaster!

What right has such a story to a place in *Discovery*? Only this, that I believe it can be shown that the origin of this twentieth-century joke lies in the activities of seventeenth-century scientists. What I take to be the first appearance of this joke, as a joke, occurs in a play called *The Virtuoso*, written in 1676 by the satirical dramatist Thomas Shadwell. The Virtuoso, otherwise Sir Nicholas Gimcrack, central character of the play, is a hilarious caricature of the seventeenth-century scientist. And one of his strange pranks runs as follows:

The scene is in London, and Sir Nicholas has guests. He suggests that they might like to take some country air. They protest that they cannot travel so far this evening. But that, says Sir Nicholas, will not be necessary. "Chuse your air," he continues, "you shall have it in my chamber; Newmarket, Banstead Down, Wiltshire, Bury Air, Norwich Air; what you will." And after the guests have suitably expressed their surprise—and their derision —he explains, "I employ men all over England, factors for air, who bottle up air, and weigh it in all places, sealing the bottles hermetically: they send me loads from all places. That vault is full of country air . . . I have sent one to weigh air at the Picque of Teneriff, that's the lightest air. I shall have a considerable cargo of that air. Sheerness and the Isle of Dogs air is the heaviest. Now if I have a mind to take country air, I send for, may be, forty gallons of Bury air, shut all my windows and doors close, and let it fly in my chamber."

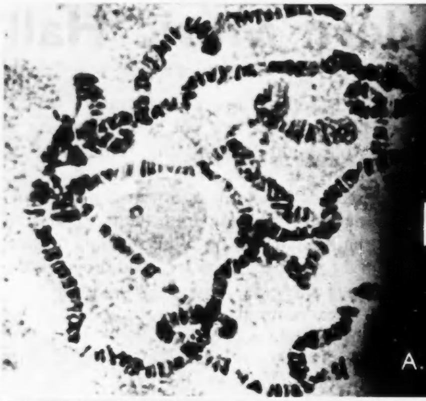
It is only my guess that this whim of Sir Nicholas's for taking country air out of bottles is the direct ancestor of the modern McTavish joke. But on the other hand, the relation of the former to the doings of seventeenth-century scientists is easily demonstrated. Experiments elucidating the properties of air—especially those of Boyle and Hooke —were among the most important achievements of science in that period. But to the layman they seemed ridiculous and unpractical. Weighing air seemed to be among the greatest follies of all, and in the play Shadwell constantly pokes fun at the idea. He gives us what amounts to a footnote reference to his source material—the mention of weighing air at 'the Picque of Teneriff' ties the Virtuoso's humours up with Hooke's *Micrographia* (1667, see page 200ff.). Thus Hooke may be considered as the unconscious progenitor of the McTavish joke.

Shadwell's satire was all the more effective because he stuck pretty closely to his scientific sources. Most of these sources have been tracked down by Claude Lloyd and published in *Publications of the Modern Language Association of America* (1929, Vol. 44, pp. 472–94). Lloyd's work makes it clear that Shadwell had first-hand knowledge of a considerable part of the scientific literature of the times. Most of his humours are got by abstracting a serious scientific work, and then adding some twist or exaggeration that turns the whole thing into an absurdity. For example, Hooke had described microscopic organisms found in vinegar, had compared them to eels in general form, but had remarked that "the wrigling motion of their body seem'd to be onely upwards and downwards, whereas that of Eels is onely side wayes. . . . And that their motion seems . . . exceedingly slow". In the play Sir Nicholas discourses on these creatures: "I'll shew you millions of them in a sawcer of vinegar; they resemble other eels, save in their motion; which in others is sideways, but in them upwards and downwards, thus, and very slow." So far this is almost direct quotation; then comes the exaggeration: "Another difference is, these have sharp stings in their tails. By the way, the sharpest vinegar is most full of 'em." Another character, of the anti-scientific party, takes him up ironically: "Then certainly the sharpness, or biting of vinegar, proceeds from those stings, striking upon the tongue"—upon which Sir Nicholas agrees in all seriousness, and pretends that the new idea was his own.

Though politically an extreme Whig, Shadwell was a reactionary in regard to science; he allied himself with those many satirists who used their wit in an attempt to stem the progressive stream of the new philosophy and to bolster up the decayed scholasticism of the past. His first-hand reading of the writings of scientists did not, apparently, give him any real understanding of the intellectual or social meaning of science. Many of his shafts, for instance, were directed towards ridiculing the uselessness of the new science. We first meet Sir Nicholas learning to swim by lying on a table and imitating a frog. His cronies give high praise to his method, and then a sceptic asks if he will try it out in water. The reply is that he has no intention of doing so—"I content myself with the speculative part of swimming, I care not for the practick. I seldom bring anything to use; 'tis not my way. Knowledge is my ultimate end." And later, when he is asked why he weighs air, he replies, "to know what it weighs. O, knowledge is a fine thing". And towards the end of the play, when a rabble of ribbon-weavers threaten to tear him to pieces on the grounds that he has invented an 'engine-loom' which is undermining their livelihood, his defence is, "I never invented any thing of use in my life".

Today some of these cracks read like justifiable satire against certain scientists who take a positive pride in the alleged uselessness of their work. But they were completely misplaced in the seventeenth century. The scientists of those times were very far from ignoring the practical applications of their work; most of them believed that even their most abstract researches would ultimately be practically useful. But they put usefulness in a new perspective—they were prepared to search out secrets of nature even when they could not foresee applications. That essentially new perspective was one of the most progressive features of seventeenth-century science; and Shadwell's play shows a complete failure to realise its meaning or foresee its consequences.

S. LILLEY, M.Sc., Ph.D.



Genes and Enzymes

By

A. R. TRIM, B.A., Ph.D.

A STRIKING feature of biology in the twentieth century has been the vast development of the study of biochemistry and genetics. Both sciences, young as they are, have yielded results of supreme importance to civilisation. Many of the achievements of biochemistry, such as insulin, vitamins and penicillin, are so well known to the layman that they are already regarded as commonplace. On the other hand genetics has still to catch the public imagination.

Biochemistry and genetics are no longer independent of one another. Like all other living phenomena, inheritance has a chemical basis, and therefore can be studied by biochemical methods. Such studies have revealed that genes, the hereditary units of the cell nucleus, control the production of enzymes, the devices whereby the cell carries out all the innumerable chemical changes, which together constitute its life process. This relationship has been suspected for many years. It would provide an adequate explanation of the early observations in the field of biochemical genetics. Recently a group of American workers, led by Professor G. W. Beadle and E. L. Tatum, started to make an investigation of the validity of this hypothesis by deliberately attempting to produce and select 'biochemical' mutations. By a judicious combination of modern techniques in genetics and biochemistry they have been able to demonstrate that the hypothesis is essentially correct, and have opened the way for further advances in our knowledge of cell chemistry.

Biochemistry is concerned with the chemistry of the materials which make up living creatures and the innumerable chemical transformations which they constantly undergo within the bodies of those creatures. The biochemist's aim has been aptly described as an attempt to discover the whole of intermediary metabolism. That is to say, the transformations which biological substances undergo between the time when they are taken in as food and the time when their ultimate products are passed out of the body as excretory materials. Great progress has already been made towards this goal and some important general principles have been established. For the purpose of this article two are of special importance. The first is that living organisms build up (synthesise) and break down chemical substances by very simple stages. The second is that each of these stages is controlled by special substances known as enzymes which are able to initiate each particular change and cause it to take place rapidly.

The principle of stepwise construction and destruction also runs through conscious human activity. The chemist building up complex molecules such as synthetic rubber, plastics and drugs by a succession of simple steps is doing, in a conscious way, the same kind of thing that the cells of his body are doing automatically and continuously as long as he remains alive. The difference between his conscious chemistry, carried out in the laboratory, and the metabolic activity of the cells and fluids which constitute his body, lies in the mechanism whereby the individual steps are achieved, even in making the same substance. For example, many living organisms make vitamin B_1; the organic chemist can also make it in the laboratory. Both the chemist and some organisms can, if compelled, start with very simple substances such as ammonia, water and carbon dioxide, but there is a world of difference between the methods employed. The chemist frequently resorts to extreme temperature and pressures and violently active chemicals, conditions which are completely destructive to all forms of life. Thanks to its enzymes an organism is able to achieve much greater feats of chemical synthesis and destruction without resort to the violence of the chemical laboratory.

We now know a great deal about enzymes. They all contain protein and some have important non-protein components. Many enzymes have even been separated from other constituents of the cell and crystallised. It seems fairly certain that every chemical change which takes place in a living organism is under the control of its own special enzyme.

Units of Heredity

The geneticists are concerned with another important biological unit called the gene which holds the key position in their general theory. This article is concerned with the relation between genes and enzymes which is now beginning to be understood. However, before embarking on a discussion of this question, it will be necessary to say something about the Genetic Theory, which is concerned with the way in which traits, such as shape and colour, are passed from one generation of an organism to the next.

In 1865 Mendel stated the Laws of Heredity. He studied some simple characters (traits) in peas and concluded that such characters must be carried from parents to the offspring by material units now called genes. Animal and plant breeders have been able to understand their observations by assuming that Mendel's Laws are essentially correct and apply to most kinds of living things. It is now clear that almost every structure and function of an organism is either directly or indirectly connected with one or more of its genes. This applies to all levels in the organism, chemical, structural, physiological and psychological.

The gene is by no means so well established an entity as the enzyme although progress has been made towards establishing its chemical nature. The genes have been located in the nuclei of all cells. They have been shown to occur incorporated in microscopic, thread-like bodies known as chromosomes. An organism has its characteristic number of chromosomes, which is usually small. The genes, which number hundreds, probably thousands, are distributed between the chromosomes in a characteristic manner.

The main chemical component of the chromosome is a complex type of substance known as nucleoprotein. The sum of evidence up to the present suggests that the fundamental mechanism of inheritance is bound up with this nucleoprotein. That is, the hypothetical gene has some kind of chemical reality which will probably be found in the complex nucleoprotein molecule.

Many factors influence the way in which a particular gene shows its effect. These include many features of the environment in which the organism carrying the gene develops. They also include conditions inside the cell such as the position of the gene in question relative to the other genes in the chromosome in which it occurs and the nature of other chromosomes present in the nuclear chromosome group to which that chromosome belongs.

Genes are not unchanging but are subject to a relatively infrequent process of, apparently, spontaneous changes

known as mutations. In a mutation a particular gene effect is suddenly changed. A common form of such mutations is the loss of a gene effect. It is possible to increase the natural rate of mutation within a population of a particular organism by various physical and chemical means. Professor H. J. Muller was recently awarded a Nobel Prize for his pioneer work on the acceleration of mutation rates by the action of X-rays and ultra-violet light on organisms. With that advance the stage was set for a thorough investigation of the relation between genes and enzymes which has been carried out by Beadle and Tatum and their school in America.

Genes Control Enzymes

It had been thought for many years that genes might exert their influence in an organism by controlling its enzymes. Perhaps there might be one gene directly in control of each enzyme. Largely as a result of the work of the American school, it now appears that some such relationship exists. From the biochemical point of view the gene is now best thought of as a unit; very probably composed of nucleoprotein, with two main functions:

(1) That of reproducing itself in such a way that exact copies of it become available to be passed to daughter cells.

(2) That of controlling the production of proteins other than those composing the genes themselves. That is to say, genes supervise the synthesis of enzymes, antibodies and possibly other proteins.

The nature of the connexion between a gene and its corresponding enzyme is still the subject of active investigation, and very little is known about it. We can only say with safety that when certain genes are changed by mutation the alteration of each one is indicated by the apparent loss of one particular enzyme. In all cases where genes and enzymes have been shown to be connected, a single enzyme has been shown to be primarily dependent upon a single gene. This is spoken of as a one-to-one relationship between gene and enzyme. In both its main functions, self-copying and enzyme production, the gene influences the synthesis of protein in an, as yet, unknown fashion.

Besides amassing some convincing evidence for the hypothesis of a one-to-one relationship between genes and enzymes, the workers on artificial mutations have provided a powerful weapon for the biochemist, who is constantly faced by the difficulty of doing chemical work with material as sensitive and complex as a living creature. Up to quite recently much of his work was done by methods whereby the organism was taken to pieces—organ by organ, tissue by tissue, cell by cell, enzyme by enzyme—and the parts studied separately. This approach has met with great success although it gives a distorted picture of what really happens in the intact creature. Now, judicious use of organisms in which suitable mutations have been produced by artificial means enables us to study the details of metabolism within the cells of the intact organism. It is encouraging to find that there is broad agreement between the results obtained by the classical methods of biochemistry and those obtained by the new genetical techniques.

The basis of theory of the control of individual enzymes by single genes was laid some forty years ago. As a result of their own experiments Correns, de Vries and Tschermak had just made their independent discovery of the Mendelian Laws of inheritance and had found Mendel's papers which showed that he had come to the same conclusions many years before. A few years later one of the early leaders of British biochemistry, Archibald Garrod, was studying the disease known as alkaptonuria, which Bateson and Punnett had shown was inherited according to the Mendelian Laws. The condition of alkaptonuria is not serious; its chief symptom is a darkening of the subject's urine when it is exposed to the air. Its interest lies in the fact that it is due to a defect in a single gene which is manifested in the loss of the ability to carry out one step in metabolism, i.e., the loss of one enzyme. This enzyme was found to be present in the blood of the normal individual but could not be found in the blood of persons suffering from alkaptonuria.

Everybody produces a substance known as homogentisic acid in the course of metabolism. The blood of normal persons contains an enzyme which converts homogentisic acid to a substance called aceto-acetic acid. That enzyme is not present in the blood of people suffering from alkaptonuria. Since homogentisic acid cannot be diverted along any other metabolic pathway it accumulates and is filtered out of the blood into the urine as the blood passes through the kidney. When the urine is passed out the homogentisic acid is oxidised to a black product by the oxygen in the atmosphere.

Garrod's Studies

The studies of Garrod and others on alkaptonuria provide the classical example of the utilisation of a genetic defect in the investigation of intermediary metabolism. Homogentisic acid is one of a series of metabolic steps whereby two important components of the food, the amino-acids tyrosine and phenylalanine, are broken down to produce carbon dioxide, ammonia, water and metabolic energy. This was demonstrated by a series of experiments on alkaptonuric and normal individuals. If tyrosine or phenylalanine are added to the diet of a person suffering from alkaptonuria there is a corresponding increase in the amount of homogentisic acid he excretes. If those two components are excluded from his diet there is a marked decrease in the amount of homogentisic acid excreted. Homogentisic acid added to the diet of the normal individual is used completely and none can be detected in the urine. Substances which are convertible to tyrosine or phenylalanine during metabolism also increase the amount of homogentisic acid excreted by the alkaptonuric patient when added to his food. If our interpretation of the metabolic role of homogentisic acid is correct, any substance which lies on the normal metabolic pathway between tyrosine, on the one hand, and homogentisic acid on the other should cause an increase in the excretion of homogentisic acid if added to the diet of an alkaptonuric patient. Two such intermediates, which will be called acids A and B for convenience, have been found. These acids are completely utilised by the normal individual and do not cause him to excrete homogentisic acid. This evidence is the basis of our belief that the metabolic pathway shown in Fig. 3 exists in the normal human being.

Beadle's Work

Facilities for carrying out this kind of work are limited, but new methods introduced by Beadle and Tatum have made it possible to adapt it for the investigation of a wide field of intermediary metabolism in certain kinds of organisms. They selected *Neurospora crassa*, the red bread mould, which is favourable for both genetical and biochemical studies. *Neurospora* is a rapidly reproducing organism with a hereditary mechanism based on the gene and chromosome, as in the higher organisms. It may be grown in test tubes on agar jelly mixed with nutrient materials. The two sexes of *Neurospora* are indistinguishable by eye, even under the most powerful microscope, and are able to procreate themselves indefinitely without mating (asexual reproduction). If the two sexes are grown together under favourable conditions, pairs of cells, one from each sex, unite and eventually, after about twelve days, give rise to a fruiting body. This body contains a number of packets of spores. Each packet is called an ascus and contains eight spores called ascospores or sexual spores. In the cases in which we are interested, where there is a one-gene difference between the two strains which have been mated, four of the ascospores will be genetically identical with the one parent and the other four with the other. Each of the eight spores can be picked out and will grow into a new colony. Another kind of spore is produced by each sex without sexual fusion. Under the right conditions these asexual spores will develop to form new colonies identical with the parent.

If the asexual spores of *Neurospora* are treated with X-rays or ultra-violet light some of them will mutate and produce what is known as a new strain. It is possible to pick out these strains, perpetuate them by asexual reproduction,

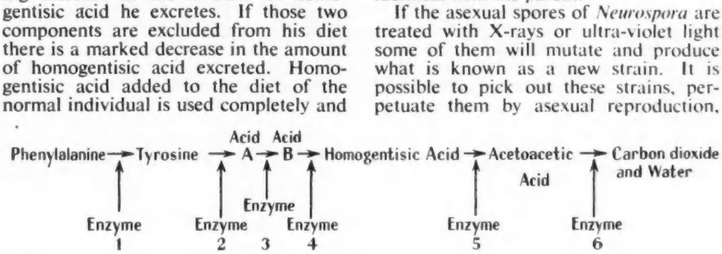
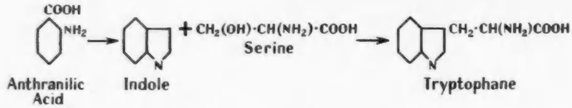


FIG. 3.

FIG. 4.



and cross them with other strains by sexual reproduction to test their genetical peculiarities.

Many of the genetical differences between strains of *Neurospora* are biochemical and may be found by testing the ability of the strain to grow on nutrient mixtures of different chemical composition. The wild strains of the mould are synthetically versatile and will grow on a very simple mixture containing water, a mixture of inorganic salts, a source of carbon and energy (usually sugar) and a single vitamin, biotin, which belongs to the B group of vitamins. All the other necessary vitamins, amino-acids, proteins, etc., are synthesised by the organism from the simple substances provided as nutrients. Many of the strains produced by artificial treatment, such as that already described, require the addition of a variety of naturally occurring organic substances before they will grow. These nutritional requirements, as they are called, may vary widely from strain to strain.

In order to find out what are the nutritional requirements of a strain it is first allowed to grow on a mixture containing an ample supply of all the vitamins and other growth substances which are known. Asexual progeny from this colony are then transferred to agar tubes containing the so-called minimal medium, that is the mixture required by the most nutritionally independent strains, which has been described in the previous paragraph. If the strain under test is unable to grow on this mixture it is transferred to tubes to which more and more of the essential biochemical components such as vitamins and amino-acids have been added. Eventually a mixture is found on which the strain will flourish.

Since the loss of the capacity to achieve a particular step in a biochemical synthesis is a common type of mutation the systematic study of strains of *Neurospora* produced artificially showed many cases in which the mutant strain had greater nutritional requirements than its parents. Dr. Tatum has recently reported that, since this work was initiated in 1941, over 90,000 cultures of *Neurospora* have been isolated from material treated with X-rays or ultra-violet light, and tested. Some 500 mutants representing about 100 different mutations have been found among them. The figures show that a relatively low proportion of the irradiated spores of *Neurospora* undergo mutations leading to increased nutritional requirements. Those which do are affected in an unpredictable way.

In spite of the deficiencies of the method it has enabled the American workers to trace the metabolic paths of important substances. For example it has shown how the amino-acid tryptophane is built up from simpler substances in *Neurospora*. Tryptophane is a very important substance and no organism can be without it. An organism which is unable to achieve the synthesis of tryptophane within its own body must obtain it from food materials. The human body is unable to make tryptophane so that it is essential for us to eat food containing it. Some mutant strains of *Neurospora* are able to synthesise their own tryptophane. Others are unable to do so. There is one of the latter, which, if given just enough tryptophane to enable it to grow, will excrete a substance called anthranilic acid into the growth medium. Starting from the same ancestral strain other biochemical variants were produced. One of them did not excrete anthranilic acid. Instead it accumulated and excreted another substance called indole, and when given anthranilic acid in the nutrient medium it produced even more indole. This showed that *Neurospora* is able to make indole from anthranilic acid. When a more complete picture had been worked out it was clear that these two compounds represented two steps in the metabolic pathway by which the organism synthesises tryptophane. Up to the present the sequence of metabolic steps shown in Fig. 4 has been demonstrated.

It was also shown by the conventional crossing methods of the geneticist that each step was ultimately dependent upon the presence of one gene. Much remains to be learned about the biosynthesis of tryptophane. Nevertheless this work has taught us some important new facts which have already facilitated important advances in other lines of biochemical research.

Beadle and Tatum's method has also revealed some interesting facts about the metabolism of the amino-acid arginine, which, like tryptophane, is a universal component of living matter. Strains of *Neurospora* were obtained which differed in their ability to deal with arginine and some of its related compounds, the amino-acids ornithine and citrulline. The complete evidence shows that in the most metabolically versatile strains ammonia and carbon dioxide are combined with ornithine to produce citrulline. Citrulline is then combined with more ammonia to give arginine. Yet another enzyme then converts the arginine back to ornithine again, and at the same time urea is released from the arginine molecule. The ornithine produced in this way will then combine with more ammonia and carbon dioxide and the whole process will be repeated. Again it was established by standard genetical procedures that each step in the synthesis of arginine is controlled by one gene. That is that the hypothesis of a one-to-one relationship between gene and enzyme is correct in this case as in the previous one.

A point of great interest in connexion with this example is that an identical metabolic path is believed to exist in mammals. Krebs and Henseleit suggested that ornithine and arginine are involved in the mammalian metabolic mechanism whereby the dangerous excretory product ammonia is converted to urea, which is removed by excretion in the urine. Krebs and Henseleit's conclusions were based on entirely different experimental methods from those employed with *Neurospora*. The striking parallel which they reveal is one of many examples of the detailed biochemical similarities which exist even between organisms as widely separated as plants and animals. The principle involved here is of the greatest importance and offers one possibility of circumventing the relative inaccessibility of the human being to biochemical experimentation. For it is certain that many metabolic changes which take place in other organisms also take place in the human body.

The biochemical similarities between diverse organisms are equally well illustrated by recent work on the vitamins. Attention was first focused on these substances because of their direct importance to human life. However, long before Hopkins and others opened up the field from the standpoint of mammalian physiology, Raulin, a pupil of Pasteur, showed that another mould, *Aspergillus niger*, required accessory food substances (i.e. vitamins) for its full growth. It has now been shown that representatives of all kinds of life require vitamins. It is also known that the same substance may be required as a vitamin by the most widely different organisms. Vitamin K, which is required by human beings and is obtained by them from plants, is also required by Johne's bacillus, the microscopic organism which causes a tubercular condition of the intestine in cattle. In mammals vitamin K is connected with the blood-clotting mechanism. The feature common to blood-clotting and the growth of a parasitic micro-organism is still quite obscure and the solution of this interesting biochemical problem may well lead to a great advance in our understanding of the nature of life.

The recent, and somewhat belated, flowering of the genetical treatment of the problems of cellular metabolism has come from the thought and work of a multitude of scientists. However, a few names are outstanding as those of workers who have given powerful and direct stimuli to this line of biological development. They are Garrod, who made the early investigations into what he called the inborn errors of metabolism; Muriel Wheldale Onslow, the plant biochemist and geneticist; J. B. S. Haldane, who re-emphasised the importance of the ideas of the earlier workers; Muller, who showed how to accelerate mutation rates; and Beadle and Tatum, who are carrying the principle into practice with such success.

(Figs. 1 and 2, at the head of this article show respectively: *Chromosomes* in the salivary gland nucleus of *Drosophila pseudo-obscura*, each chromosome being seen as a ribbon banded with genes separated by bands of unstained protein; crystals of the enzyme pepsin. Fig. 1 is from a photomicrograph by Dr. P. C. Koller, magnification 2500 times.)

READING LIST

G. W. Beadle, *Chemical Reviews*, 1945, Vol. 37, 15.

Essays by J. B. S. Haldane and R. Scott-Moncrieff in *Perspectives in Biochemistry*, Cambridge University Press, 1937.

Science and the Industrial Worker

"The health of industry depends on certain complicated technical factors, and on the complicated mechanisms called human beings. The former are easy to handle compared with the kind of problem that the latter present." These opening words of Dr. R. E. Lane, Professor of Industrial Health at Manchester University, set the key for the British Association Conference on 'Human Factors in Industry', held at Leamington Spa on May 8.

The conference was divided into two sessions: the first, 'Working Conditions', dealt with the physical environment, and the second, 'Human Relations', with the socio-psychological factors. Sir Henry Tizard, President of the British Association and Chairman of the Government's Advisory Council on Scientific Policy, was chairman at the opening session.

Professor Lane said that there was much information on human industrial problems which was not used, due to ignorance rather than wilful neglect. There was also insufficient collaboration between industry and the research associations. Many research workers needed to leave their ivory towers and mix in the hurly-burly of industry.

The doctor had the task of seeing that the worker was fit for the job, and that the job was fit for the worker. Environmental conditions went farther than industrial disease and lighting and heating. They included the general psychological atmosphere. Often the doctor was the first to become aware of a condition of stress in a department, and he could by timely action prevent the development of more serious trouble. To do that he had to have the confidence of employer and employees. He must be inside industry, and not merely attached to it. "Let us remember", said Professor Lane, "that 'Production comes from people', and they need just as much expert care as do the machines they attend. That care must often be individual, and the doctor is perhaps the best person to bring to this problem a perspective in which the human being occupies the principal place."

Dr. C. L. Cope, F.R.C.P., who directs research on human problems for the National Coal Board, gave details of the great trail of human wastage from accident and disease in the coal industry. For instance, deaths on the job average about 550 per year; and accidents sufficiently severe to cause an absence of more than three days number 180,000 per year, and have been rising steadily for years.

He said that many aspects of the miner's working environment were under active review, and real efforts were being made to introduce improvements as rapidly as possible. What effects these would have on human productivity could scarcely be predicted. But he did not wish it to be assumed that he considered the environmental conditions were more important from this viewpoint than the human relations factors.

Drs. H. C. Weston and T. Bedford, both of the Industrial Health Research Board, read papers on 'Lighting' and 'Heating and Ventilation', respectively. The latter pointed out that any improvement in working conditions tended to help the poor workers rather than the good ones.

Sir George Schuster, chairman of the second session, who is chairman of the Industrial Productivity Committee's Panel on Human Relations, said our great problem today was to make employment in industry the basis of a good life in the highest sense. They had to show that industrial employment was not out of harmony with the things that man wants for himself as a human being. The real question was how to influence the conduct of industry in its present state, how to deal with human beings obsessed with their present problems, at what point to intervene and what method to use.

Dr. T. G. Tredgold, of the Roffey Park Rehabilitation Centre, said that far too little was known about the relations of people in industry. Besides *recognising* the need for social skill, they must also *inculcate* the need for social skill.

Incentives

Mr. D. Chapman, of the Liverpool University School of Social Sciences and Administration, said there was considerable resistance by workers to the operation of financial incentive schemes, because they believed that these were employed in the long run to reduce piece rates and as a means of selecting slower workers for dismissal. Today large numbers of operatives were by no means convinced that full employment was anything but temporary, and they were unwilling, therefore, to consider changes in the organisation of their work which might weaken their position if unemployment returned. There was also an unwillingness to consider additional effort partly because of P.A.Y.E., and because additional earnings would not provide domestic extras.

The approach must be to understand the working group concerned. To tackle production problems by exhortation on a national scale had little or no effect. The financial incentive would play an important part, but its effectiveness would depend on the total situation. The problem was to devise ways whereby absence and lateness might be reduced, new methods of working including redeployment be accepted, the attention of the operative directed to finding ways of reducing effort, and co-operation increased between individual operatives, groups of operatives, and operatives and management. The resistances would only be overcome if the initiative for improvement came from below as the result of the understanding and agreement of the working group itself. The trade union branch should share responsibility with management for improved methods.

Dr. A. T. M. Wilson, of the Tavistock Institute of Human Relations, thought that incentives were linked to a primitive view of human motivation. It was the concept of the donkey, the carrot and the stick. Although it was still commonly accepted, it was an extremely dangerous idea on which to base policy, because it provided no basis on which to predict human action.

There were three fundamental observations in the study of men. First, that from the beginning we were members of groups. Secondly, that our behaviour was enormously influenced by the groups of which we have been, or are, members. And thirdly, there was a most remarkable contrast in the behaviour of human beings inside, and outside, the family. Therefore, the differences of behaviour were related to the human conditions that existed in 'the works-role'.

He believed that an urge to constructive activity was a natural impulse in human beings; and that in the absence of imposed discipline men would themselves establish a discipline. "Even if you have goodwill towards work people you cannot impose that goodwill on workers," he said.

Mr. Alec Rodger, senior psychologist to the Admiralty, summed up the day's discussion. He could not agree that the industrial medical officer should act as a kind of super-adviser. Those who had spoken on working conditions had given a convincing demonstration that in some parts of the field a great deal had been accomplished by orthodox scientific procedures. But he reminded them of the Hawthorne experiment of the American General Electric Company (details of which can be found in *Management and the Worker*, by Dickson and Roethlisberger, Harvard Univ. Press) and said that the real starting point for investigation was when improved conditions had secured increased output. He thought we ought to do similar experiments in this country.

They had to recognise that many scientists regarded with great distaste the emphasis on short-term projects to solve immediate problems. They ought to make full use of conventional scientific procedures of observation and experiment. Too many people were inclined to think that the problems were too complicated for that. That was because some types of investigator did not like to use statistics. The help of the expert statistician was indispensable.

They had to participate more readily in the co-ordination of their investigations. There were too many investigations of hardly any value, because they could not be linked up with other work. They needed to have groups of recognised experts in each part of the field to scrutinise thoroughly the investigations. They needed also to find better means of getting their findings to those concerned. They must use simple language, helped out by straightforward pictorial representation. They needed to make much more use of journalists with a scientific bent and scientists doing journalistic work. Also, they needed to get the administrator to show more appreciation of scientific method. There was a tremendous need for a study of the resistances to improve techniques. MAURICE GOLDSMITH.

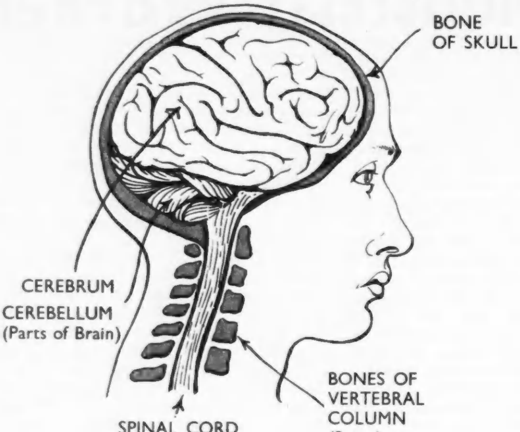


Fig. 1.—This diagram shows the arrangement of the central nervous system (brain and spinal cord).

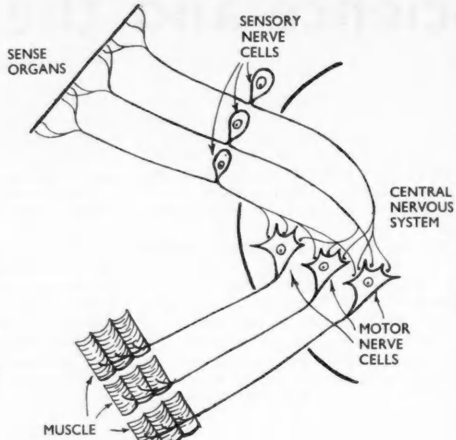


Fig. 2.—How the nervous system links sense organs with effector organs (muscles or glands).

JUNIOR SCIENCE

How Nerves Work

If the nerves leading to your fingertips are cut you can no longer feel anything with the fingertips. Yet in the very first of these articles I said that feeling things with your skin depends on sense organs in the skin, and cutting a nerve does not directly affect the sense organs. The reason why cutting a nerve can affect what you feel is that sense organs only work if they are connected to nerves.

The nerves lead to the *central nervous system* (Fig. 1). The central nervous system is made up of *the brain*, which is inside the bone of your skull, and *the spinal cord* which runs down inside the bone of the spine (or vertebral column). The central nervous system is composed mainly of *nerve cells* and *nerve fibres*; each fibre is really part of a cell. Fig. 2 is a diagram showing how nerve cells and fibres are arranged. (You will remember I mentioned nerve fibres when I described the retina of the eye in the February issue.) Each nerve is a bundle of these very fine fibres.

You can get an idea of how your nerves play a part in feeling if you think of what happens if you bang your funny-bone. You get the worst pain if you bang one particular point, and it's just at this point that a nerve runs over the bone. Now the pain you feel seems to be very largely in your little finger, and not at the elbow. This is because the nerve is the one that connects on to the sense organs in the little finger. In other words, a blow on the nerve produces the same sort of sensation as though a lot of the pain organs it's connected to had been stimulated.

You cannot prove, that nerves do all this, without a lot of experiments, and most of the experiments need apparatus and animals to experiment on. But there's one quite simple experiment you can try yourself. Take a pin, and try to see exactly what happens when you are pricked with it; say, on the back of the finger, just below the nail. Give yourself a fairly light prick, and take the pressure off at once. Try it now, before reading on, and observe carefully *exactly* what you feel; perhaps it is best to get a friend to administer the prick, while you keep your eyes closed and concentrate on what you feel. . . . Now I'll tell you what I feel when I do this experiment. The first thing I notice is obvious: there's a slight, sharp pain; at the same time as this I can also feel the pressure of the pin—which is a different sensation. You only notice the pressure for the moment that the pressure is kept on. The pain dies away. But then *pain comes back again* for a moment, and dies away once again.

What is the explanation of this double sensation—first *touch plus pain*, and then *pain alone*, with an interval of about a second between them? Any feeling depends on messages being carried by nerves to the central nervous system. In this case there are two kinds of nerves: the ones that carry the effects of touch (plus some pain) conduct messages more quickly than the ones responsible for most of the pain; both lots of messages start at the same time, but the ones that cause the second pain get left behind. So they reach the central nervous system about a second later than the others. If you try the experiment on your ankle instead of your finger the messages have farther to go to the central nervous system, and so the slower ones get left behind even more. As a result the interval between the two feelings is more than a second. Try it for yourself and see if you can detect the difference.

Each nerve fibre carries messages at a definite speed, but the speed varies a good deal with the different fibres. The highest speed is over 200 miles an hour. But when I say the fibres carry 'messages' do not think I am comparing them with telephone or telegraph wires. Fibres are not like wires at all: they work quite differently, and what we do know about how they work is too complicated to describe here.

Some fibres, as I have said, carry messages from the sense organs *inwards*, to the central nervous system, but others carry them *outwards*, from the brain. I said just now that, if you cut a nerve, that may lead to loss of sensation. That is due to cutting fibres that carry messages inwards. But there is another result of cutting some nerves: it causes *paralysis*. Paralysis is a state of affairs in which the muscles don't work; a paralysed limb is one that cannot be moved. (Of course, paralysis can be produced in many ways: cutting a nerve is only one of them.) You get paralysis when some nerves are cut because every muscle has its own nerve supply; in the ordinary way a muscle contracts only when messages are carried to it by its nerve fibres from the central nervous system.

To see how the two kinds of nerve work together let us consider the train of events that follows from shining a light in somebody's eye. You will remember that when I wrote about the eye I said you would be able to see that the pupil contracts, and I hope by now you have tried it. When you shine the light the first things affected are the light detectors in the eye: messages go back from them, in the eye nerve, to the brain; these messages, or *impulses*, stimulate part of the brain to send more impulses out, in another nerve: this nerve goes to the muscle that causes the pupil to get smaller when it contracts (like a piece of string pulled tight round the mouth of a sack). When the impulses

reach this muscle it does contract, and so you observe a reduction in the size of the pupil. So the train of events is: *detection* of the light—*transmission* of impulses to the brain by nerves attached to the light detectors—*stimulation* of part of the brain—*transmission* of impulses by other nerves from the brain to the muscle—*contraction of the muscle*.

This sort of thing happens in response to all kinds of stimuli. A stimulus is anything outside your body that affects any of your sense organs. In the example I have just given the stimulus is the light shone in the eye. Whenever a simple stimulus brings about a simple response in the sort of way I have described the whole sequence of events is called a *reflex*. Fig. 2 illustrates the various structures that take part in a reflex. Next month I shall have more to say about reflexes. ANTHONY BARNETT.

Far and Near

Scientific Photographs Wanted

THE Royal Photographic Society, whose 93rd annual exhibition is to be held during September and October this year, is anxious to make known that the exhibition is open to entries from *all who use photography, and not merely from members of the Society*. Scientific, Nature, Technical and Record Photography is catered for in the second section of the exhibition, and it is hoped that this part will again be fully representative of the best modern work in the field. It should provide a standard against which those who use photography in technical work can judge their own results.

Photographs produced in the course of research work are particularly welcomed, especially if they illustrate the use of photography for obtaining information unobtainable by any other means. All entries should have full descriptions provided upon the mounts to ensure that the full purpose of the work and value of the results are obvious to all. Judging is competitive and two medals are awarded for the best work in certain classes.

There is no entrance fee. Entries must be entered before *July 24th, 1948*. Entry forms, rules and full particulars can be obtained from: The Secretary, The Royal Photographic Society, 16 Prince's Gate, London, S.W.7.

Unesco's Summer School for Librarians

THE first International Summer School for Librarians, sponsored by Unesco, will be held in England during September. Mr. Raymond Irwin, Director of the School of Librarianship, University College, London, will direct the school which will be held successively in London and Manchester. Librarians who may wish to attend the school should contact their national library association which will furnish complete details.

Other Summer Schools

A COURSE of lectures for laymen and scientists who want to study the role of science in modern society has been organised by the Educational Centres Association (8 Endsleigh Gardens, London, W.C.1). This summer school has been arranged for August 28–September 4 at Westham House, Barford, near Leamington, Warwickshire. Further details can be found in our advertisement columns.

A summer school in Electron Microscopy will be held this year in the Cavendish Laboratory, August 18–24. It is intended for those who have some familiarity with the instrument and who are already, or in the near future will be, operating it in physical, chemical or biological laboratories.

A detailed syllabus and form of application for admission may be obtained from G. F. Hickson, M.A., Secretary of the Board of Extra-Mural Studies, Stuart House, Cambridge.

A summer school in the Physics of Solids, with particular reference to the properties of ionic solids, will be held in the H. H. Wills Physical Laboratory of the University of Bristol, beginning on September 8 and ending on September 15. Lectures will be given by Professor N. F. Mott, Dr. J. W. Mitchell, other members of the staff of the laboratory, and research workers from this country. Applications should be sent to Mr. W. E. Salt, The University, Bristol 8.

British Association at Brighton

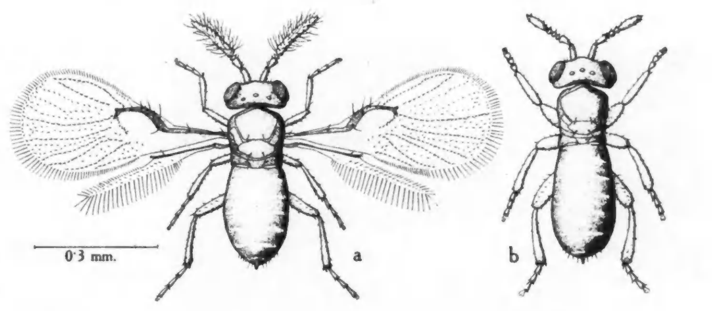
THE British Association has published the Preliminary Programme of the 110th Annual Meeting, which will be held in Brighton from September 8 to 15. The programme for this year's Meeting at Brighton is again topical and of wide general interest. It includes addresses and lectures by distinguished men of science, and discussions on topics such as: Achievements of X-ray analysis; newer metals and alloys in industry; geology today and tomorrow; biology in schools; colonial development; movements of population in the Commonwealth; the metric system; building materials; human blood groups; colour vision; changing aspects of nutrition; selection of university students; problems of old age; maintenance of world food supply; forestry and the community. Copies of the Programme may be had on request to the Secretary of the Association, Burlington House, Piccadilly, W.1.

New Light on Classification

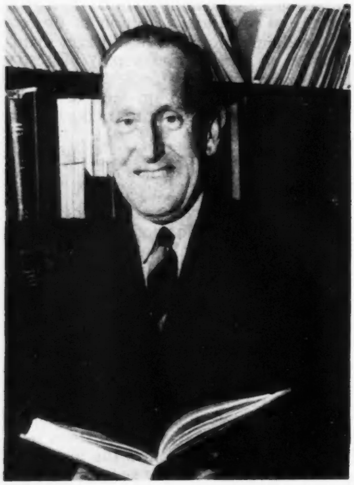
THE SYSTEMATICS Association, which caters for those interested in the study of systematics in relation to general biology and evolution, recently arranged a series of exhibits at the Natural History Museum. The aim was to show how a systematist goes about his work, and about fifteen tables were occupied with exhibits illustrating such varied topics as the use of egg patterns of mosquitos by Mr. P. F. Mattingly, paleontology without fossils in the bird wing butterflies by Mr. A. G. Gabriel and Professor F. E. Zeuner, graphical methods of analysing statistical data by Dr. J. P. Harding, and the mineralogist's conception of a species by Dr. Campbell Smith.

Many of the exhibits were concerned with the polymorphism of species: Mr. E. B. Britton showed several examples in beetles where the males of a species appear in more than one form while the females are all alike; Mr. J. F. Perkins showed two males of a hymenopteron parasitic on the eggs of insects, one being a wingless form not otherwise imperfect or degenerate in any way and the other with many quite different characters including the presence of wings. Both belong to the same species, and which form the male assumes depends on whether it was reared in an alder fly's or a moth's egg. Dr. D. L. Gunn demonstrated some live locusts where the two forms *solitaria* and *gregaria* depend on whether the young hoppers grow in isolation or under crowded conditions. One exhibit was a cage full of gregarious hoppers which marched round and round an electric lamp all in the same direction and with a characteristic rhythm of alternate short runs and little hops.

Dr. A. S. Corbet had a very striking exhibit showing how the modern classification of the butterfly genus *Euploe*



The chalcid Trichogramma parasitises insect eggs. Males reared on moth's eggs (left) are winged, those reared on alder fly eggs lack wings (right). See 'New Light on Classification' (Figure after Salt, "Parasitology", Vol. 29, p. 543).



Mr. J. E. Cummins, former head of the Information Service of Australia's Council of Scientific and Industrial Research, has come to London to direct the Australian Scientific Liaison Office.

based on dissection cut right across the old ideas based on wing colour and pattern. He had examples of six species of the genus from a number of different islands in the Malay Archipelago. Each species varied considerably from island to island in the wing pattern; but there was a striking similarity between all the species on any particular island. On one island all the species were blue in colour, on another the same six species were all brownish with white markings especially near the margins. It is thus comparatively easy to say from the wing pattern what island a specimen comes from but in order to determine the species, less evident characters such as the structure of the genitalia have to be used. The explanation, it seems, is not that the special environment of each island affects each species in the same way; but that a special type of mimicry (called Mullerian mimicry) is involved. The species are probably all distasteful and the enemies on each island learn to avoid eating butterflies with a particular wing pattern. Natural selection keeps the pattern the same for all species on any one island but since the populations of butterflies and enemies on each island are isolated from those of other islands, there is nothing to prevent the patterns on two islands from changing gradually and drifting apart provided all the species on an island change in unison.

Miss Theresa Clay showed that the lice parasitic on flamingoes were more like those of ducks and geese than those of storks and herons, and suggested that this might help ornithologists to decide where to place the flamingoes.

Mr. David Lack's work on Darwin's finches was illustrated by his film of the Galapagos fauna. The most interesting shot was of a finch using a twig as a tool for probing insects out of crevices.

Lighting Exhibition at Science Museum

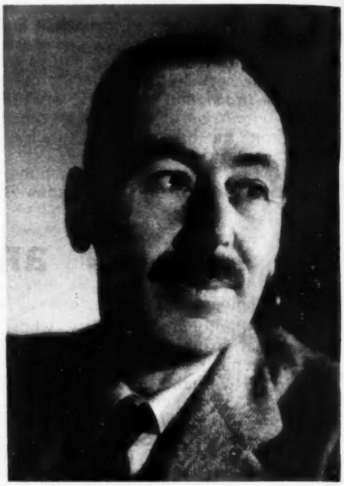
A SPECIAL exhibition at the Science Museum which is open until the end of September illustrates how, after 4500 years of almost negligible progress, the application of research methods has produced a crescendo of discovery in the past 150 years. The sociological significance of lighting, both during the period of stagnation and that of progress, has been overlooked by most historians, and in the handbook to the exhibition, *Darkness into Daylight* (Stationery Office, 1*s*.) by W. T. O'Dea, an attempt has been made to evaluate such factors as well as describing, in simple terms, the scientific discoveries that have made possible the developments of modern times.

Geoffrey Pyke

THE date of Geoffrey Pyke's death was February 21, 1948, and not as given in the May issue (p. 147). Confirmation or correction of the date we gave had been sought from Mr. Pyke's son in Germany, but owing to postal delays the information we asked for did not reach us until after the May issue had been published.

Gas Turbine for Road Vehicles

THE first gas turbine engine designed for road vehicles was the highlight of the Power Jets (Research and Development) Ltd. section of the Ministry of Supply Stand at the B.I.F., Birmingham. This engine, said to be the smallest gas turbine



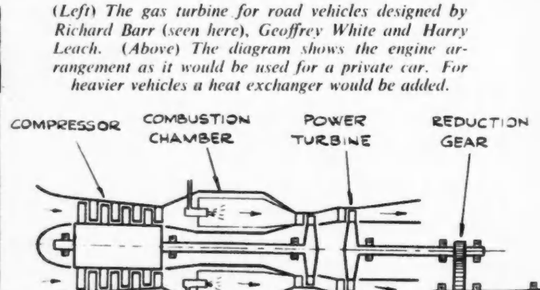
Mr. E. Bolton King, new director of the British Council's Science Department. An expert on rockets, he has worked on guided missiles for The Ministry of Supply.

unit in the world, was invented by Mr. R. H. H. Barr, Mr. G. White and Mr. H. Leach, all of whom were former members of Power Jets and are now actively concerned with Centrax Power Units Ltd., a company formed in 1946 to design and build small gas turbines.

The particular model on show comprised only the 'gas generator section', as the power turbine which is coupled to the transmission is not included. The official statement described it as a 160 brake h.p. unit which can be used as a portable high-speed generator, a marine engine, or a light aircraft engine. At present no R.A.C. rating can be given, but it could be compared approximately to that of a conventional petrol engine of 35–40 h.p.

Although no gear change except for reverse or clutch is required to drive a car, it is acknowledged that for the heavier types of vehicles a two-speed gear-box may be necessary. Its fuel is Diesel oil and consumption should compare favourably with that of the equivalent petrol engine.

(Left) The gas turbine for road vehicles designed by Richard Barr (seen here), Geoffrey White and Harry Leach. (Above) The diagram shows the engine arrangement as it would be used for a private car. For heavier vehicles a heat exchanger would be added.



Some of the main dimensions are: diameter, 17 inches; overall length from starter motor to reduction gear box, 5 feet; weight, 250 lb.

Following upon the disclosure of details about this engine, the Rover Company revealed that it has constructed and is testing an even smaller unit of the same type. The R.A.C. rating for the Rover engine is 25 h.p., and it develops 100 h.p., running on paraffin instead of the Diesel oil used in the Centrax engine.

British Council's Science Director

MR. E. BOLTON KING has been appointed Director of the Science Department of the British Council. An Oxford graduate in Physics, he carried out research at the Clarendon Laboratory, largely on photoelectricity. Later he formed the Oxford Instrument Company. Early in the war he joined the Ministry of Supply Rocket Team under Sir Alwyn Crow and was engaged on rocket development, and as an assistant director of the British Commonwealth Scientific Office he was responsible for liaison with rocket development in the U.S.A.

Castle Roofs in the Air

A TECHNIQUE for supporting roofs literally 'on air' is described in *Nature* (1948, Vol. 161, p. 613) by Herbert H. Stevens. Mr. Stevens gives these details of one pressure-supported roof which proved successful; the roof was semi-cylindrical, 25 feet in radius, 200 feet long and built of sheet steel on formwork which was supplanted by air pressure (half a pound per square inch) after the ends had been closed with a flexible connexion and the floor rendered airtight. This structure was built in 1934 at Minneapolis and was used as a grain bin (holding 70,000 bushels) for a year.

One modification of this technique (the principle of which is familiar enough to everyone who has seen an ordinary gasometer of the non-rigid type) is described in British Patent 591985.

Overseas Scientific Relations Committee

THE Government is setting up an Inter-departmental Committee on Overseas Scientific Relations to consider and advise on questions of United Kingdom Government policy on matters of overseas scientific relations. The chairman is Sir Edward Appleton, G.B.E., K.C.B., F.R.S., and in addition to representatives of Government departments, the membership will include the foreign secretary of the Royal Society, representatives of the British Council and of the Conference of Research Associations, and two university scientists. The secretary of the committee is Mr. H. L. Verry, Head of the Overseas Liaison Division, D.S.I.R., 142 Piccadilly, London, W.1. (*Telephone*: Grosvenor 3961.)

A.Sc.W. Membership

MEMBERSHIP of the Association of Scientific Workers had reached the figure of 18,449 by the end of 1947. According to the annual report presented to Council last month, this total was made up of 8,178 full members, 8,974 associate members and 1,297 students.

Science and Socialism

BRITISH politicians have been forced to recognise the importance of science in modern society, and in addition they have come to recognise that it is worth wooing the scientists and technologists as voters in the present period when the result of a General Election may largely depend on how a million or so 'unattached' voters mark their ballot paper. The Communist Party seems to have been the first to set out deliberately to gain the support of scientists. The Labour Party which has shown in the past only slight *official* interest in science is now busy making up for lost time in this direction, and a committee has been set up to thrash out a scientific policy for the party which can be presented before the next election. A sign of the times is the appearance of a Labour Party discussion pamphlet, which is published, however, not as an expression of party policy but as the opinion of one individual. Entitled "Science and Socialism", it has been produced by Ritchie Calder, the pamphlet being written at the top of his form. One of the most impressive sections is a summary of the 'New Deal' which he says the Labour Government has given to science; he lists the following examples of its encouragement to science: the new salary scales in the Scientific Civil Service ("The scale of salaries can at least compete with industry," claims Calder); university science has benefited from increased Government grants, which have risen from £3 million before the war to £12 million a year; the establishment of the DSIR stations for hydraulics, radio and mechanical engineering; research in Scotland is being encouraged with the setting up of the Mechanical Engineering Research Station, and also sub-stations of the Building, Road and Fuel Research Stations. Mr. Calder speaks of the Government spending a total of £70 million on scientific research and development. He also stresses the significance of the Government's Advisory Council on Scientific Policy, the Defence Research Policy Committee and the Committee on Industrial Productivity.

U.S. to produce Radium Substitute

COBALT 60, which has been described as the most promising substitute for radium, is to be produced under the auspices of the U.S. Atomic Energy Commission. In making this announcement, Mr. D. E. Lilienthal, A.E.C. Chairman, stated that Cobalt 60 would be safer to handle but had a limited life compared with radium.

British and U.S. Atomic Weapons

THE U.S. Atomic Energy Commission on April 19 announced that there had been a test of an atomic weapon at the Commission's proving grounds on Eniwetok Atoll in the mid-Pacific Marshall Islands. For security reasons the date and nature of the test was not announced. Last month it was officially stated that the test involved three different types of atomic weapons. The Commission announced last July that proving grounds at Eniwetok were being established "for routine experiments and tests of atomic weapons".

The British Minister of Defence, Mr. A. V. Alexander, referred in Parliament on May 12 to the development of atomic weapons by Britain in these words: "As was made clear in the Statement Relating to Defence, 1948 (Cmd. 7327), research and development continue to receive the highest priority in the defence field, and all types of modern weapons, including atomic weapons, are being developed." He refused to elaborate upon this statement.

Father of Brain Surgery

JUNE 22 brings a centenary well worthy of note. For William Macewen, born 100 years ago, who was very much a Glasgow man since he was educated there and became professor of surgery at Glasgow University and surgeon to the Royal Infirmary where Lister worked, was the father of brain surgery as well as doubling his role by becoming pioneer in bone surgery. Lister was first applying his famous antiseptic treatment when Macewen was medical student there. When Lister passed on, it was Macewen who became acknowledged as Britain's leading surgeon. 1876 brought his first diagnosis, that of a boy with an abscess in the frontal lobe; and although Macewen was not permitted to operate, the post-mortem proved that his surgery could well have saved a life. Then just 70 years ago he removed a tumour from a brain; a year later he successfully operated for subdural haemorrhage; and later still introduced an improved technique in his operation for mastoids—this after recognising a common cause of brain abscess in diseases of the middle ear. By 1880 he had introduced bone grafting with small grafts replacing missing parts. On this occasion a second boy regained the use of an arm. Those crying out against experimental work on animals might well read up Macewen's remarkable methods, a sure proof of benefits acquired for the well-being of man. Lister is well known; Macewen has almost been forgotten.

Danger of New Insecticide

WARNING against the dangers of using sodium selenate as an insecticide was given last month by Dr. Hubert Martin of the Long Ashton Research Station. He said it might cause sterility in animals and might make hair drop out and nails fall off. The evidence on which the warning was based is being published in the Station's annual report.

The Bookshelf

One Story of Radar. By A. P. Rowe, C.B.E. (Cambridge University Press, London, 1948; pp. 206, 8*s.* 6*d.*).

"YOU can say anything you like in Rowe's office on a Sunday," Air Chief Marshal Sir Philip Joubert once remarked during the last war. The spirit of this remark—an intimate and entirely democratic co-operation between the civilian research scientist and the serving officers of high and low rank who used the results of his work—pervades this book, and is perhaps one reason why the Allies and not Germany won the war. The author, who was Chief Superintendent of T.R.E. from 1938 until the end of the war, states in his preface that this is not the story of radar: "It is no more than one man's story of one Experimental Establishment belonging to one Government Department." There is indeed little of the official war history in this account of the Telecommunications Research Establishment. It is largely a personal story written in an extremely warm, human style and with its fair share of humour, yet it effectively conveys the sense of urgent purpose behind the vast research programme of radar for the R.A.F. The balance between the main story, technical detail and minor incident is skilfully maintained; there is skill, too, in portraying the interaction of research and strategic problems—as, for instance, in the explanation of why Fighter Command's radar needs were foreseen so much earlier and more clearly than those of Bomber Command.

To all those interested in applied research and the workings of research establishments this book should make fascinating reading. The book recounts the formation of the Tizard Committee; the birth of radar as an idea arising out of an acute need in the country's defence plans, and Watson-Watt's application to this need of a technique taken from a totally different sphere of research; the keen, stimulating atmosphere of the early days at Bawdsey; the later stages at Dundee, Swanage and finally Malvern. It tells the inspiring story of the birth of centimetric wave technique and the moral courage of the men who saw it through at a time when Britain seemed near defeat, and describes many other aspects of the work and life at T.R.E.

The book renders a valuable service to Government Research Establishments in that it offers to young scientists an attractive picture of an atmosphere of freedom of ideas and experiment; it does much to dispel the feeling that scientists in such establishments are either frustrated and dictated to by headquarters in London or browbeaten by senior Service officers. The author's views on secrecy in relation to research are also worth noting.

The book is attractively made up and well indexed, and there are several good whole-page photographs. D. S.

Radio Aids to Navigation. By R. A. Smith. (Cambridge University Press; London, 1947; pp. 114, 9*s.*).

THIS book, written by a man who worked on navigational aids at T.R.E. during the war, gives a comprehensive account of the many radio aids to navigation which are available today. Something of the history of each piece of equipment is given as well as a sufficient account of the principles on which it operates.

The author deals fairly with the advantages and limitations of various systems, whether of British, United States or German origin, and stresses the point that, while it is now possible for an aircraft to navigate with equal precision in conditions varying from perfect to zero visibility, no practical means exist for ensuring safe landings in bad flying weather.

In a book of this size some assumptions must be made. Here it is assumed that the reader is familiar with the problems of air navigation and airfield control, and that he is acquainted with modern radio and radar principles.

R. P. H.

An Introduction to Crystallography. By F. C. Phillips (Longmans, Green, London 1947; pp. 302, 500 diagrams, 25*s.*).

TO SAY that "this is yet another text-book on crystallography" is true. It may also be said that it follows the pattern of many of its forerunners, but with distinctive differences. Intended as an introduction to crystallography for the chemist, physicist, or mineralogist, it will serve as a balanced background for the tutor. Its illustrations are outstanding. Although entirely line drawings they have achieved excellence through their accuracy and execution by a draughtsman skilled in the art of perspective. Similar lavish praise of the text is deserved, but here and there brevity has resulted in ambiguity. In the first chapter of this orthodox, even classical, approach to crystals, too little space is accorded to the fundamentals of symmetry, form and habit, and goniometry. Since such are intended as the basis to the theme of the book it is probable that the student will be handicapped by an all-too-brief account of, say, the operative essentials of goniometry. On the other hand, few could desire a more excellent discourse on the Hermann-Maugin notation for the thirty-two classes—probably the first time this concept has been incorporated into a text-book on crystallography.

The studied avoidance in this book of X-ray diffraction studies of crystals may well provoke comment. This important aspect could well have been included to 'round off' this brilliantly executed text-book. However, Professor Phillips contends that early discourses on the subject of X-ray crystallography forces upon the student a conception of a crystallographic pattern which is based upon a space lattice which he cannot investigate until well advanced in his studies.

Consequently, he has set aside all this and has devoted the whole book to a systematic approach by visual observation of crystals and a graphic annotation of the results. Despite this apparent shade of incompleteness, this book is destined to be a 'standard work' which, in the hopes of the author, will enable students to "finally lay it aside and, throwing off the shackles of the text-book", set out upon their own crystallographic investigations.

W. DAVID EVANS.

Adventures in Man's First Plastic. The Romance of Natural Waxes. By Nelson S. Knaggs. (Reinhold, New York; Chapman and Hall, London, 1947; pp. 329, 40*s.* 6*d.*).

THIS is a book most likely to appeal to the lay reader, telling a simple but interesting story of natural waxes, their origin, how they are collected and the hundreds of different uses that have been found for them. The history of the candle, of lithography and of the phonograph all come within the author's purview. Probably it will attract a certain number of more technically informed readers, who alone would read the last chapter which is very compressed and very miscellaneous; for their benefit, too, are tables setting out the properties of various waxes. There is also a useful bibliography.

Theoretical Aerodynamics. By L. M. Milne-Thomson. (Macmillan, London, 1948; pp. 363, 40*s.*).

IN this book Professor Milne-Thomson applies to the subject of aerodynamics the treatment which he used so successfully in his previous book on theoretical hydrodynamics, and as one would expect, the result is a clear and well-presented exposition of the mathematical aspects of aerodynamics.

Starting from basic conceptions the chapters lead through Bernoulli's theorem, two-dimensional motion, and rectilinear vortices to the circular cylinder as an aerofoil. Then follows Joukowski's transformation, theory of two-dimensional aerofoils, and thin aerofoils. Coming to three-dimensional flow, aerofoils of finite aspect ratio, lifting line theory and lifting surface theory are examined. The remaining chapters deal with propellers, wind-tunnel corrections, subsonic and supersonic flow, simple flight problems, moments, stability, and finally vectors. 320 exercises are included.

The reader is expected to have a knowledge of elementary differential and integral calculus, but the author very commendably always explains any particular mathematical point which arises in the discussion, which is a tremendous help to the reader who is not a mathematician. The omission of the chapters on flight problems and stability, which strictly belong to Theory of Flight, would, in the reviewer's opinion, have improved the book, but this is a small point compared to the general excellence of the major part of the text. This is a book which can confidently be recommended.

J. B.

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